
HARVARD UNIVERSITY
ARNOLD ARBORETUM
PRESENTED BY CHARLES SPRAGUE SARGENT
1892

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOLUME VII, 1917

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
THE WAVERLY PRESS
BALTIMORE, MD.

Vol. VII   No. 1

January 4, 1917

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Journal of the Washington Academy of Sciences

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

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VOL. VII JANUARY 4, 1917 No. 1

PHYSICS.—*Luminescence measurements.*[1] N. E. DORSEY, Bureau of Standards.

Although the excitation of phosphorescence by the radiations from radioactive substances was early observed it appears that no quantitative measurements of the luminosity thus produced were published until 1910. In that year Marsden[2] published a series of observations which showed that the luminescence of certain materials (zinc sulphide, willemite, and barium platinocyanide) hermetically sealed in tubes containing radium emanation decreased much more rapidly than the emanation decayed, and that the rate of decrease increased with the amount of emanation initially present. He reported only relative values. At the same time Rutherford[3] advanced a theory to account for these phenomena, and showed that it agrees with Marsden's observations, within the limits of experimental error.

No later measurements of such luminosities have apparently been published, although the subject is one of considerable scientific interest. Latterly the subject has become of much practical importance, owing to an increasing use of self-luminous preparations containing radioactive excitants. Besides being used for the illumination of watch dials, push buttons, etc., these preparations have a wide field of usefulness in war appliances.

In the study and testing of these preparations we are confronted with the problem of measuring surface luminosities of

[1] A contribution from the Bureau of Standards.
[2] Proc. Roy. Soc., **83**: 548–561. 1910.
[3] Proc. Roy. Soc., **83**: 561–572. 1910.

small areas of various sizes and shapes. Also, it is desirable that the apparatus employed be simple in construction and use, and that the results obtained be readily interpretable in terms of photometric standards.

As the luminosities frequently are low, photometers of the usual types would be unsuited to the work even if their use did not necessitate a determination of the effective size of the preparation under study. With preparations of sufficient brilliance the spectrophotometer will give the most detailed information; but this instrument is not suitable for the measurement of the total luminosity or for the comparison of such luminosities when they differ in color.

Other apparatus or methods that have come to our attention—such as those employed by Wood,[4] Nichols and Merritt,[5] Zeller,[6] and Andrews[7]—all appear to be in some measure ill-adapted to the present problem. The apparatus described by Andrews is the simplest, but we believe that the interpretation of its readings in terms of photometric standards will be difficult.

In preparation for the study of self-luminous materials at the Bureau of Standards, a photometer has been devised which is exceedingly simple in construction and use, and appears to be well suited to much of this work. By the use of standardized lamps and screens the results obtained by its use can be interpreted readily in terms of photometric standards.

In its simplest form, this photometer consists of a box 2 or 3 meters long and 25 or 30 cm. square. A light carriage carrying a 1.5 or 2-candle electric lamp runs on ways extending the entire length of the box, the filament being in the center of the section of the box. By means of two cords attached to the carriage, one passing over a pulley at the rear end of the box, the distance of the carriage from the end of the box can be adjusted as desired. The position of the lamp is determined by a graduated steel tape having one end attached to the carriage.

[4] Wood, R. W., Phil. Mag. (6) **21**: 209–313. 1911.

[5] Nichols, E. L., and Merritt, E., Phys. Rev. **23**: 37–54. 1906; **32**: 38–53. 1911.

[6] Zeller, C. A., Phys. Rev. **31**: 367–375. 1910.

[7] Andrews, W. S., Gen. Elec. Rev., **19**: 892–893. 1916.

Both ends of the box are closed, but in the front end is set a milk-glass window 2 or 3 cm. square, backed by a color filter so chosen as to make the transmitted light match in color the luminescent light that is to be measured. In the bottom of the front end of the box there are suitable openings through which pass the cords for operating the carriage, the steel tape, and the leads carrying the current to the lamp. The entire interior of the box, including the ways and the lamp carriage, is painted a dead black, and movable black diaphragms and screens must be so placed as to screen the milk-glass window from all light scattered from the walls of the box. All joints must be light tight, and the openings through which the cords, etc., pass must be suitably screened or provided with black cloth hoods to prevent the passage of light. It is desirable that the top of the box be hinged, so as to facilitate the adjustment of the diaphragms and lamp.

The photometer is used in a darkened room. As the luminosities with which we are concerned are often quite faint, any stray light, such as may leak under a door, becomes very annoying and should be carefully excluded. In the lamp circuit are placed a suitable ammeter and adjusting rheostats. Unless there is a second observer whose sole duty it is to keep the current at the proper value, the current should be supplied by a storage battery being used at the time by no one else.

In order to make a measurement, the luminous material, applied to a card or enclosed in a thin walled glass tube[8] of small diameter, may be placed directly against the milk-glass screen and the position of the lamp is then adjusted by the cords until the luminosity of the milk-glass appears to be the same as that of the material. The observer's line of sight should be perpendicular to the milk-glass. If the color match is good the tube will almost disappear when the adjustment is correct. The luminosity of the material is inversely proportional to the

[8] The tube should be painted black over two-thirds of its circumference, so as to screen the milk-glass from the light given out by the material. The unpainted side is turned toward the observer and the tube is rotated so as to reduce the visible dark line on one side to the smallest amount consistent with a screening of the milk-glass.

square of the distance of the lamp from the milk-glass screen, the constant of proportionality being determined from a careful photometric standardization of the lamp and of the screen and color filter as used. For example, the photometer screen and a certain specimen were found to be of equal brightness when the lamp was 70.5 cm. from the screen. The lamp was a tungsten lamp burning at the color of a 4 wpc carbon lamp and had a candlepower of 1.38 in the direction of the length of the photometer. For the light from such a source the surface brightness of the screen used had been found to be 3.96 microlamberts per meter-candle illumination from the rear. Consequently, this specimen had a surface brightness of $3.96 \times 1.38 \div (0.705)^2 = 11.0$ microlamberts. A microlambert is the brightness of a perfectly diffusing and completely reflecting white surface when illuminated by a source of unit candlepower placed at a distance of 10 meters.

When greater precision is desired, the top of the milk-glass window should lie in the central section of the end of the photometer and be so placed that the vessel containing the material under study can be placed immediately above it and so thatthe luminescent surface lies in the plane of the window. For the highest precision it is desirable that the material be contained in a thin vertical vessel with sides of thin plane glass and bottom of thin material so that the two luminous fields can be brought as nearly as possible into contact, so as to secure a minimum visibility for the line of separation.

In addition to the well known errors of ordinary photometry, others of prime importance have to be guarded against. For low luminosities it is necessary that the eye of the observer be in a highly sensitive state; this condition is not attained until after he has been in total darkness for at least 15 or 20 minutes. In order to retain this sensitive state the illumination used for reading the scale, recording the observations, or other purposes must be as faint as is consistent with the work, and must be continued only as long as is absolutely necessary. Furthermore, this light must be of such a nature that it will not affect the luminosity of the material under study. These

conditions may be practically attained by the use of a small pocket flashlight suitably screened and provided with a ruby bulb.

In order that the luminosity of the preparation shall be due solely to the radioactive excitant, it is necessary that the preparation shall have been excluded from all light except its own for at least several hours before the measurement is made. During the measurements the milk-glass window must in every case be screened from all light coming from the preparation; otherwise a false setting will be obtained. The error due to this cause may easily amount to over 10 per cent in the luminosity.

Another error that must be carefully guarded against at these luminosities is that due to the "Purkinje effect." By this is meant the fact that two adjoining luminous surfaces of different colors that appear to be of equal brightness when viewed from a certain distance will not appear to be of equal brightness when viewed from a different distance. This means that when we are dealing with different colors our judgment of equality of brightness is a function of the intensity of the illumination. This effect becomes very pronounced at low intensities. A further difficulty is introduced by the fact that under such conditions the judgment of equality of brightness depends upon the peculiarities of the eye of the observer; different observers judge differently. On account of both of these reasons it is important that the illuminated milk-glass be a very close color match to the material being measured. This is true even when the luminosity is so low that it produces practically no color sensation, properly so called. Under such conditions the color match must be determined by spectroscopic examination; indeed this is the best procedure in all cases.

By the addition of a phosphoroscope and a constant source of illumination this photometer can be readily adapted to the study of the intensity of the luminescence excited by light, especially when the spectrum of the luminescence is a single broad band. If the luminiscence consists of a number of narrow bands scattered throughout the visible spectrum an exact

color match will in general be impossible, and difficulty may then arise from the Purkinje effect.

MINERALOGY.—*Mineralogic notes.*[1] ESPER S. LARSEN and GEORGE STEIGER, Geological Survey.

I. APHROSIDERITE FROM BRITISH COLUMBIA

Introduction. A highly fossiliferous Cambrian shale or slate from the Burgess shale near Field, B. C., examined by the authors for Dr. Charles D. Walcott, carries numerous veinlets of pale green chlorite with some associated pyrite and calcite. A study of this chlorite shows that it is related to aphrosiderite. The authors are indebted to Dr. Walcott for the material here described.

The slate[2] is very fine-textured, so fine that much of the material shows aggregate polarization. It is made up largely of muscovite with some kaolinite, a very little quartz, apatite, and pyrite. Numerous dark brown to black streaks arranged parallel to the cleavage represent carbonaceous matter. An analysis of the slate, made by George Steiger, is given in column 1, table 1. It closely resembles the analysis of sericite from Dürrberg shown in column 2. The chlorite occurs in a system of rudely parallel veinlets less than a millimeter across, which are normal to the slaty cleavage; the rock tends to break through the centers of these veinlets, leaving surfaces lined with small grains of calcite and blotches of cupriferous pyrite.

Physical properties. The chlorite is light-green in color, it has a hardness of about 1 or 2, and the powder analyzed had a specific gravity, as determined by the picnometer method, of 2.959, which was probably not changed by the admixed muscovite by more than $\pm$ 0.01. It fuses with difficulty.

In thin section the chlorite makes up most of the veinlets, but there is more or less calcite in irregular crystals in the center of the veins and some pyrite. It is nearly colorless in thin section

[1] Published with the permission of the Director of the U. S. Geological Survey.

[2] WALCOTT, C. D., *Cambrian Geology and Paleontology—II*, Smithsonian Misc. Coll. 67: 149–51. 1914.

and is so faintly birefracting that it is easily mistaken for an isotropic mineral. It is probably very finely crystalline. Its index of refraction as measured by the immersion method is 1.625 ± 0.003. No further optical data could be determined. No cleavage was observed. Aphrosiderite from Weilburg, Prussia,[3] is optically positive, and has the following indices of refraction and pleochroism:

$$\alpha \text{ and } \beta = 1.612 \pm 0.003; \text{pale olive-green.}$$
$$\gamma = 1.616 \pm 0.003; \text{colorless.}$$

Chemical analysis. The aphrosiderite gelatinizes with hydrochloric acid. Material for an analysis was carefully selected, but the best sample contained a good deal of the mica slate and a little pyrite and calcite. The calcite was removed by dilute acetic acid and the analysis was then made on that portion of the remaining sample which was soluble in HCl. The results of the analysis by George Steiger are given in column 3 of table 1. Column 3a gives the results for the acid soluble portion computed to 100 per cent. Column 3b gives the molecular ratios and columns 4 and 5 give the analyses of related chlorites for comparison. The analysis shows that the chlorite is near aphrosiderite and that it has the empirical formula $64(Fe,Mg)O.24Al_2O_3.42SiO_2.60H_2O$, which is near $5(Fe,Mg)O.2Al_2O_3.4SiO_2.5H_2O$ and between the formulas assigned to aphrosiderite and delessite.

II. THURINGITE FROM COLORADO

A chlorite, differing from that described above as aphrosiderite chiefly in the higher content of both ferrous and ferric iron and in the presence of considerable manganous oxide, occurs in large amount as a primary mineral in several of the veins near Creede, Colorado. The veins are of considerable size and occupy great fault fissures. The filling of the vein on which are the Ridge and Solomon mines in East Willow Creek consists largely of this chlorite with a little quartz, fluorite, and the ore minerals, galena and sphalerite. The great Amethyst vein is made up

[3] Unpublished manuscript by Esper S. Larsen.

largely of amethystine quartz containing galena, sphalerite, and some streaks and bodies of the chlorite; it carries much silver and some gold. The veins are in great flows of rhyolite,

TABLE 1

ANALYSES OF SLATE AND CHLORITES

	1	2	3	3a	3b	4	5
SiO_2	54.49	55.80	22.68	24.97	416	26.45	25.72
Al_2O_3	25.60	27.72	21.58	23.76	233	21.25	20.69
Fe_2O_3	0.89	3.07	1.41	1.55	10		4.01
FeO	2.00		24.40	26.86	373	44.24	27.79
MgO	1.18	0.53	9.81	10.81	269	1.06	11.70
CaO	1.90	0.14	tr.	tr.			
Na_2O	0.28	1.51	0.24	0.26	4		
K_2O	6.67	5.62	0.88	0.97	10		
H_2O-	0.33		9.72	10.71	595	7.74	10.05
H_2O+	3.91	4.03					
TiO_2	0.72		0.10	0.11			
ZrO_2	None						
CO_2	1.54						
C	Not det.						
P_2O_5	0.08						
SO_3	None						
S	0.24						
MnO	None						
BaO	None						
SrO	None						
CuO	tr.						
Insoluble			8.57				
	99.83	98.42	99.39	100.00		100.74	99.96
Less O	0.09						
	99.74						

1. Middle Cambrian slate from British Columbia.

2. Sericite from Dürrberg. Quoted by Dana, System of Mineralogy, 6th edition, p. 618, analysis 41.

3. Analysis of aphrosiderite from near Field, B. C. George Steiger, analyst.

3a. Analysis of aphrosiderite computed free from gangue. Sp. Gr. = 2.96.

3b. Molecular ratios of 3a.

4. Analysis of aphrosiderite from Weilburg. Sp. Gr. = 2.8. Quoted by Dana, System of Mineralogy, 6th edition, p. 660, analysis 1.

5. Analysis of aphrosiderite from Bonscheerer. Sp. Gr. = 2.991. Quoted by Dana, System of Mineralogy, 6th edition, p. 660, analysis 3.

which are very low in magnesia and iron, and the chlorite and other minerals are largely vein fillings rather than replacements.

The chlorite is green in color and is soft and friable. It is fibrous to platy and is finely crystalline.

An optical study of the chlorite from various parts of the Creede district shows that it varies somewhat in its optical properties and no doubt also in chemical composition. The material analyzed from the Last Chance mine on the Amethyst vein is in very minute interwoven fibers of positive elongation and optically negative character. The axial angle is moderate. The mineral is pleochroic: dark green parallel to the fibers (β and γ) and nearly colorless normal thereto (α). The mean index of refraction is about 1.637 ± 0.005 and the birefringence is about 0.01. The fibers are too small for a satisfactory optical study. A specimen of the mineral from the Park Regent mine, also on the Amethyst vein, showed essentially the same optical properties, but the indices of refraction are slightly higher ($n = 1.643$). A specimen from the Amethyst mine gave $\beta = 1.638 \pm 0.003$.

A specimen from the Ridge mine is considerably paler in color, is less strongly pleochroic, is a little more coarsely crystalline, and has lower indices of refraction, but is otherwise similar. It is optically negative and has a moderate axial angle. X is normal to the fibers and plates and is very pale green; Z and Y are a somewhat darker olive-green. The refractive indices are: $\alpha = 1.595 \pm 0.005$, $\gamma = 1.605 \pm 0.005$. Another specimen from the Ridge mine consists of very minute fibers and has a mean index of refraction of about 1.585 ± 0.005. A specimen from the Solomon mine is similar but its mean index of refraction is 1.617 ± 0.005.

These data indicate a moderate range in the composition of the chlorite. The mineral from the Ridge-Solomon vein with its lower index of refraction is probably higher in Al_2O_3 and lower in Fe_2O_3 and higher in MgO and lower in FeO. It approaches aphrosiderite or delessite in composition. The analysis of the gouge from the Solomon mine (analysis 4, table 2), which was made up largely of chlorite but contained some quartz and

chalky decomposed rhyolite with here and there a flake of sericite, confirms this conclusion.

The thuringite from the Amethyst vein and the chlorite from the Ridge-Solomon vein are both fusible at about 4 and become magnetic on ignition. The thuringite decomposes in acid with imperfect gelatinization.

A chemical analysis of thuringite from the Last Chance mine on the Amethyst vein, a few miles above Creede, is given in column 1 of table 2. The material analyzed contained a little admixed quartz. Other analyses of thuringite are given in columns 2 and 3 for comparison, and in column 4 is given the analysis of the gouge from the Solomon mine, which, as already

TABLE 2

ANALYSES OF THURINGITE AND GOUGE

	1	2	3	4
SiO_2	24.34	23.58	23.70	55.25
Al_2O_3	16.46	16.85	16.54	12.10
Fe_2O_3	12.04	14.33	12.13	1.28
FeO	28.89	33.20	33.14	10.71
MgO	5.41	1.52	1.85	9.30
CaO	None			0.34
Na_2O	0.37	0.46	0.32	0.28
K_2O	tr.			0.39
H_2O-	0.35	10.45	10.90	1.49
H_2O+	9.19			6.70
TiO_2	tr.			0.15
CO_2	tr.			0.11
P_2O_5	tr.			tr.
S	tr.			0.11
MnO	2.75	0.09	1.16	1.43
Total	99.80	100.48	99.74	99.64

1. Thuringite from the Last Chance mine near Creede, Colorado. J. G. Fairchild, analyst.

2. Thuringite, Harpers Ferry. J. L. Smith, analyst. From Dana's System of Mineralogy, 6th edition, p. 657, analysis 5.

3. Thuringite, Arkansas. J. L. Smith, analyst. From Dana's System of Mineralogy, 6th edition, p. 657, analysis 7.

4. Gouge made up largely of chlorite, from the Solomon mine near Creede, Colorado. J. G. Fairchild, analyst.

mentioned, is made up largely of the chlorite of that vein but contains some quartz, some chalky decomposed rhyolite, and a few flakes of sericite.

The three analyses of thuringite are very much alike, but the Creede mineral is lower in ferrous oxide and correspondingly higher in magnesia and manganous oxide; its somewhat higher content of silica may be due to admixed quartz.

III. GRIFFITHITE, A NEW MEMBER OF THE CHLORITE GROUP

Introduction. The authors have hesitated before proposing a new name for a member of the chlorite group, already overburdened with names that have little significance and less place in a systematic scheme of classification. However, a chloritic mineral filling amygdaloidal cavities in a basalt collected by Mr. R. T. Hill from Cahuenga Pass, Griffith Park, Los Angeles, California, differs so greatly, both optically and chemically, from any of the chlorites previously described as to require a new name, and the name griffithite, from the locality, is proposed for the mineral. The amygdules of the basalt are up to an inch in largest dimension and comprise a considerable part of the rock; they are pure griffithite.

Physical properties. The griffithite is dark-green in color, it has a hardness of about 1, is sectile, and has a specific gravity, as measured by the picnometer method, of 2.309. It is in basal plates and shreds, and some of the plates are a millimeter across. It has the usual cleavage of the chlorites. It fuses at about 4 with intumescence to a black magnetic slag.

Optical properties. It is optically negative and $2V$ varies from 0° to 40°; X is normal to the cleavage. It has a strong birefringence and a rather strong pleochroism. The indices of refraction differ in different grains as much as 0.01; they and the pleochroism are:

$\alpha = 1.485 \pm 0.01$; pale yellowish,
$\beta = 1.569 \pm 0.005$; olive-green,
$\gamma = 1.572 \pm 0.005$; brownish green.

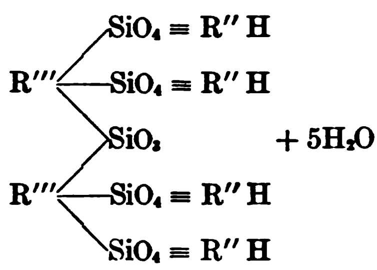
Chemical properties. Griffithite gelatinizes with HCl. The material selected for the analyses showed under the microscope almost no impurities; its optical properties varied as indicated in the preceding description. The analysis by George Steiger is given in column 1 of table 3; the molecular ratios are given in column 2.

TABLE 3.

ANALYSIS AND MOLECULAR RATIOS OF GRIFFITHITE

	1	2	
SiO_2	39.64	657	= 5 × 131
Al_2O_3	9.05	89	= 1 × 135
Fe_2O_3	7.32	46	
FeO	7.83	109	= 4 × 138
MgO	15.80	392	
CaO	2.93	52	
Na_2O	0.71	11	
K_2O	None		
H_2O-	12.31	684	= 5 × 137
H_2O+	4.90	272	= 2 × 136
TiO_2	None		
	100.49		

The ratios lead to the formula $4(Mg,Fe,Ca)O.(Al,Fe)_2O_3.5SiO_2.7H_2O$ for griffithite. Prof. F. W. Clarke has kindly proposed the formula $H_4R''_4R'''_2Si_5O_{19} + 5H_2O$, or



ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOPHYSICS.—*Mechanics of the Panama Canal slides.* G. F. Becker. U. S. Geological Survey Professional Paper 98-N. Pp. 253–261, with 3 figures. 1916.

After describing the essential features of the breaks on the Culebra Cut the author points out that there is a limit to the depth of a vertical cut in an homogeneous isotropic mass, the upper surface of which is plane. This limit is that at which the pressure is sufficient to produce simple shear in the mass, and in a concluding note reasons are given for believing that $6\sqrt{2}$ multiplied by the resistance to such shear is about equal to the ultimate strength under linear compression. The depth at which one-sided relief of pressure will produce simple shear is called y_1.

It is shown that in such a bank the profile of a surface along which the mass is strained to the elastic limit must be a form of the elastic curve, the directrix of which lies at a depth y_1.

The lowest or basal slide curve is one which intersects the horizontal bank at right angles. Examples are worked out for this and other cases.

A complete analogy exists between the form of these curves and those which the surface of water assumes when it rises by capillarity between vertical, parallel glass plates.

In view of these results the author discusses to some extent the formation of ruptures, the bulging of the canal bottom, and the effect upon pressure of the form of the banks. The paper includes a note on finite strains. G. F. B.

PHYSICS.—*The freezing point of mercury.* R. M. Wilhelm. Bureau of Standards Scientific Paper No. 294. Pp. 6. 1916.

The temperature at which mercury freezes is of importance in thermometry. It marks the lower limit to which mercurial thermometers may be used, and its location, at about −39°C., makes it of value as a

fixed point of the temperature scale below 0°C. This paper gives the result obtained and describes in detail the method used at the Bureau of Standards in making a redetermination of this constant. The temperature measurements were made by means of platinum resistance thermometers whose constants had been previously determined by calibration at 0°, 100°, and 444.6°C. (the boiling point of sulphur). All the evidence at present available indicates that, down to −40°C., the platinum resistance thermometer, calibrated as above, defines temperatures that are in agreement with those given by the standard gas thermometer. The value, −38.87°, obtained at the Bureau is in very good agreement with that found by Henning in 1913 at the Reichsanstalt, Germany. He also used platinum resistance thermometers and obtained −38.89°C. C. W. W.

MAGNETISM.—*The determination of the degree of uniformity of bars for magnetic standards.* Raymond L. Sanford. Bureau of Standards Scientific Paper No. 295. Pp. 14. 1916.

Magnetic standard bars are used for the calibration of permeameters and for the comparison of methods of magnetic testing. One requisite of such a bar is that it shall be magnetically uniform along its length. If this condition is not fulfilled, errors may arise which can not be calculated or eliminated from the measurements, and which may be of considerable magnitude. In this paper it is shown how the degree of magnetic uniformity of a bar may be determined from observations of the distribution of magnetic leakage along the length of the bar when it is magnetized between the poles of a suitable electromagnet. The degree of uniformity is indicated by the values of the rate of change of leakage along the length of the bar. Deviations of these values from a constant indicate the presence of non-uniformities. An increase in the value indicates a magnetically hard spot while a decrease indicates a soft spot. The method may also be applied to the examination of magnetic materials for mechanical inhomogeneities and for the detection of flaws. R. L. S.

GEOLOGY.—*Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho.* E. L. Jones, Jr. U. S. Geological Survey Bulletin 640-E. Pp. 83–111, with 1 map. 1916.

The Boise Basin lies near the western edge of the irregular mountainous area between the Salmon and Snake rivers in Idaho. The basin structure is ascribed to the sinking of a fault block approxi-

mately 15 miles long and 12 miles wide. The Basin is underlain dominantly by the granite of the great Idaho batholith, which is believed to be of late Cretaceous or early Tertiary age. During Tertiary time most of the Basin was occupied by a lake, and deposits of clay, sand, and gravel accumulated. Lava flows were erupted during and after the deposition of the sediments.

Since the discovery of gold in 1862, Boise Basin has produced over $53,000,000 in precious metals. Of this amount the greater part was obtained from placers, but since the depletion of the gravels the lode deposits have been receiving more attention. The placer gold was derived from the disintegration of veins that occur in a belt of porphyritic dike rocks and in zones of shearing in the granite. The lodes now being worked are chiefly valuable for their gold and silver content, but with improved milling methods lead, copper, and zinc will probably add materially to the output. Monazite occurs abundantly in the placers but is not utilized. An unidentified radium-bearing mineral was found in placer gravels at one locality. E. L. J., Jr.

GEOLOGY.—*Tin ore in northern Lander County, Nevada.* Adolph Knopf. U. S. Geological Survey Bulletin 640-G. Pp. 125–138. 1916.

Tin ore has recently been found in northern Lander County, Nevada. The stanniferous mineral is exclusively wood tin, a form of stannic oxide concentrically banded like exogenous wood. It occurs in narrow veinlets traversing a series of rhyolite flows of middle Tertiary age; in places the veinlets are sufficiently closely spaced to form low grade lodes, but because of the small amount of development work so far done not much is known of the persistence and tenor of these lodes. The minerals associated with the wood tin are specular hematite, lussatite (a fibrous form of silica resembling chalcedony), chalcedony, tridymite, and opal. The deposits resemble closely those of the Mexican states of Durango, Zacatecas, and Guanajuato, but the association of wood tin with abundant tridymite and lussatite appears to be distinctive of the Nevada occurrence. A. K.

ENGINEERING.—*Colorado River and its utilization.* E. C. LaRue. U. S. Geological Survey Water Supply Paper 395. Pp. 231, with 25 plates and 5 figures. 1916.

The region traversed by the Colorado and its tributaries is one of great interest in every respect. Various government bureaus have investigated certain questions pertaining to the water resources of

the basin, much exploratory work has been done under private auspices, irrigation and power projects have been examined, railroad routes have been surveyed, and the Grand Canyon has been traversed by several persons and parties since Major Powell made the pioneer trips in 1869 and 1872.

The information relating to the water resources that has been collected by many agencies has never been brought together so that a broad view of the possible utilization of the whole river could be obtained. The present report attempts the pioneer work of assembling the principal facts relating to the subject, and especially of studying the possibility of controlling the flow of the whole river by means of storage reservoirs, in order to avoid further danger of overflow to the Salton Sink and to render available for profitable use the enormous quantity of water that now flows unused and largely unusable to the Gulf of California in the form of floods. B. D. W.

TECHNOLOGY.—*Durability of stucco and plaster construction.* R. J. Wig, J. C. Pearson, and W. E. Emley. Bureau of Standards Technologic Paper No. 70. Pp. 72. 1916.

In 1915 the Bureau of Standards in cooperation with a committee which includes representatives from the Supervising Architect's Office of the Treasury Department, the American Concrete Institute, and three contracting plasterers of wide experience and from as many large cities, as well as representatives from the industries, undertook a comprehensive investigation of stucco construction. On the Bureau's grounds was erected a test structure containing 56 experimental stucco panels, each approximately 15 feet long and 10 feet high. These panels, which were completed in November, 1915, represent practically all of the common types of stucco construction, a variety of mixtures being used on metal lath, wood lath, hollow tile, brick, concrete block, plaster board, gypsum block, and concrete bases.

In April, 1916, a careful inspection of the condition of the panels was made, and the present progress report and full description of the test structure was prepared. Only 2 of the 56 panels were entirely free from cracks six months after the panels were erected, and a number of them were in very poor condition. On the other hand, about 40 per cent of the panels were rated as satisfactory. It should be mentioned that the smooth type of finish employed is well adapted to the bringing out of the small defects, such as cracks, blotches, uneven texture, etc. Further experimental work is needed before general conclusions can be drawn. R. J. W.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 777th meeting was held on October 28, 1916, at the Cosmos Club. President BRIGGS in the chair; 50 persons present. The minutes of the 776th meeting were read in abstract and approved. The Chair informed the meeting of the death on the morning of October 28, 1916, of Mr. CLEVELAND ABBE, a charter member of the Society.

Mr. A. H. TAYLOR presented an illustrated paper embodying the results of an investigation in collaboration with Messrs. E. C. CRITTENDEN and F. K. RICHTMYER on *A normal eye for the photometry of lights of different color*. Individuals in general differ in their judgment of the relative brightness of lights which differ in color. Consequently, in order to assign definite values to such lights it is necessary to establish some common basis of comparison and to provide means for reducing to this common basis the results obtained by different observers. For measurements of incandescent lamps it has been proposed to test observers by having them determine the relative transmissions of a reddish-yellow (potassium bichromate) solution and a blue-green (copper sulphate) solution. This paper is a report of a trial of this method. For large color differences a flicker photometer must be used, and the size and brightness of the photometric field must be specified, to make the results definite. The conclusion reached was that the method proposed does give a practical means of establishing a normal eye and of reducing to the normal value the results obtained by any group of observers.

The paper was discussed by Mr. MIDDLEKAUFF, who referred to the intercomparisons at various laboratories of a series of glasses for the purpose of establishing a basis for the calibration of other color screens. The use of the flicker photometer necessitates no change in the photometric standards already adopted by the Bureau of Standards.

Mr. W. W. COBLENTZ then spoke on *The relative sensibility of the average eye to lights of different colors*, giving the results of an investigation by himself and Mr. W. B. EMERSON. The paper was illustrated by lantern slides. In the present investigation the methods were practically the same as those used by previous experimenters. In the visual measurements, the spectral light was compared with a standard white light by means of a flicker photometer, also by an equality-of-brightness photometer. The source of white light was a standard-

ized vacuum tungsten lamp. A cylindrical acetylene flame was used as a source of spectral light. The distribution of energy in the spectrum of the acetylene flame was determined with great care, in view of the fact that the disagreements in previous work seemed to be due, in part, to uncertainties in radiometrically evaluating the light stimulus. Sensibility curves were obtained for 130 persons, of which number 5 were color-blind. The visibility curve of the average normal eye, using 125 observers, was found to be wider than previously observed. These data, obtained by the use of a flicker photometer, were given. Only a few observers were able to make accurate settings with the equality-of-brightness photometer.

As was to be expected, the visibility curves of no two persons appear to be exactly alike. When a visibility curve does not coincide with the average there is usually a marked departure from the average visibility in a given spectral region. This gives rise to (1) wide visibility curves with the maximum shifted toward the red, i.e., "red sensitive," (2) narrow curves with a sharp maximum in the green, and (3) curves with the maximum shifted toward the violet. The data available indicate that among a group of persons having normal color vision about 20 per cent are (1) red sensitive, (2) blue sensitive, or (3) average, while in 10 per cent of the cases examined the color sensibility falls below the average (1) in the red or (2) in the blue or (3) falls below the average in both the red and the blue, thus giving rise to an apparently high sensitivity in the green. One person in 20 has a very wide visibility curve, while 4 per cent are color-blind, i.e., they confuse colors. The point of maximum sensibility was found to be very different for different observers; for the 125 persons the mean maximum is at $\lambda_m = 0.5576\ \mu$. The curve of average visibility, when corrected for the selective transmission of the ocular media, including the yellow spot, is very symmetrical.

An empirical equation of the visibility curve determined was given. Using this visibility equation and Planck's equation of black-body radiations, calculations were given of the luminous energy emitted by a black body at various temperatures; also the luminous efficiency, the Crova wave-length, and the mechanical equivalent of light. Using the recent measurements of the brightness of a black body, as determined by Hyde, Cady, and Forsythe, and the most probable values of the radiation constants ($C_2 = 14{,}350$, $\sigma = 5.7$) the value is 1 lumen = 0.00161 watt of luminous flux; or 1 watt (of radiation of maximum visibility) = 621 lumens = 49.5 candles. The direct determination of 613.5 lumens of green mercury radiation, $\lambda = 0.5461\ \mu$, (made by Ives, Coblentz, and Kingsbury, using 61 observers) when corrected for visibility V (at $\lambda = 0.5461\ \mu$) = 0.985 V_m gives 622.8 lumens per watt, in good agreement with the present determination.

Discussion. Mr. EMERSON emphasized the importance of taking the last observations; if only the first 40 had been used the curves would have been shifted. Mr. WHITE asked whether the two eyes of an ob-

server could always be considered alike. Mr. Coblentz stated there was no great reason for testing the possible difference between the eyes of the observer. Mr. Swann referred to the limit of sensitivity of the human eye. Mr. Wenner noted that the visibility curve, as measured, depends on many things. What difference would there be by using equal-energy spectrum or equal light throughout spectrum? Mr. Coblentz thought that any difference would depend upon the stimulus started with. Mr. Taylor stated that it was very interesting to note the efficiency of ordinary illuminants. Mr. Wells referred to the practical application to photometry.

Informal communications. Mr. W. F. G. Swann presented an informal communication, *On the absorption of energy by an electron.* In order that an electron may absorb an appreciable amount of energy from a wave falling upon it, it is frequently considered that the energy of the wave must be concentrated in a filamentary manner, the idea being that the electron can only take energy from a cross section of the advancing wave comparable with the cross section of the electron. That such an assumption is necessary has never appeared very conclusive to the author, and the object of this work is to point out that if the difficulty of an electron's absorbing energy from a cross section of the wave, large compared with its own cross section, be admitted, we must confront this same difficulty in problems of much simpler nature than those which are generally quoted as the problems which give rise to the difficulty. Thus, suppose an electron to be placed in a uniform field X of magnitude 1 volt per cm. The work done on it by the time it has moved a distance x is Xex. If we calculate the volume W of the original field which would contain energy equal to this amount, remembering that the energy density is $\frac{X^2}{8\pi c^2}$, we readily find $W = \frac{8\pi exc^2}{X}$. Thus by the time the electron has moved 0.05 cm. in a field of 1 volt per cm., it will have absorbed energy equivalent to that contained in a volume of the original field equal to 18×10^{-8} cc., or in a sphere whose radius is about 3×10^{-3} cm. or 3×10^{10} times the radius of an electron.

The 778th meeting was held on November 11, 1916, at the Cosmos Club. President Briggs in the chair; 42 persons present. The minutes of the 777th meeting were read in abstract and approved.

Mr. G. K. Burgess presented a communication, illustrated with lantern slides, on *The resistivity and thermoelectric properties of pure iron.* There were described the apparatus and experimental methods used and results obtained in exact measurements of the resistance and the true thermoelectric power of pure iron over the temperature range 0° to 1000°C. Both series of measurements were taken in vacuo at 2° intervals using iron 99.968 pure. The characteristics of the transformations A_2 at 768° and A_3 at about 910°C. and the lack of other

transformations were demonstrated. These experiments are described at length in the following: Bureau of Standards Scientific Paper No. 236 (Burgess and Kellberg on Electrical Resistance) and No. 296 (Burgess and Scott on Thermoelectric Power) also in abstract in this JOURNAL (6: 650. 1916).

Discussion. Mr. L. J. BRIGGS asked what method was used to get the iron pure from the electrode. Mr. BURGESS stated that after prying off the iron from the electrode it was melted in a crucible of magnesia and then drawn out after melting in vacuo; the stock of pure iron is kept in a vacuum. Mr. WHITE spoke of the difficulty of obtaining homogeneous iron and asked whether the iron used was thermoelectrically homogeneous. Mr. WRIGHT referred to recent experiments at the laboratory of the General Electric Company in which the analysis of the structure of iron was made by the use of X-rays, and discussed the crystalline structure of silicon-iron and electrolytic iron.

By invitation Mr. L. H. ADAMS then gave an illustrated communication on *The effect of positive and of negative pressures on the resistance of metals.* The effect of pressure on the resistance of metals was first noticed by Chwolson. His work and that of Lussana and others were briefly reviewed, and a short account was given of the various attempts that have been made, notably by Koenigsburg and by Grüneisen, to place the variation of electrical resistance with pressure upon a theoretical basis. Pure hydrostatic pressure apparently always decreases the resistance of pure metals by an amount which varies from about 1 to 30 parts per million per atmosphere. Many alloys, however, exhibit a positive pressure coefficient of resistance. The change in resistance of metals under pressure finds an important practical application in the measurement of very high pressures. Pressure gauges may be constructed of a coil of manganin or of "therlo" wire with an appropriate method for measuring small changes of resistance. Such gauges show no hysteresis and there is apparently no upper limit of pressure to which they may be used. Changes in resistance are also observed when tensile stresses are applied to metallic wires. Results were shown for the metals copper, platinum, silver, and "therlo." Now, since a tensile stress may be resolved into a negative hydrostatic pressure and two sets of shearing stresses, and since, moreover, preliminary experiments showed that shearing stresses produced no changes in the resistance (at least none greater than 10^{-8} per kg./cm.^{2}), it would seem reasonable that there should be a simple relation between the two coefficients of resistance—hydrostatic and tensile—provided only that each coefficient be properly corrected for the known elastic deformation. Results for four metals, however, failed to confirm this supposition. But it is worthy of mention that the corrected tension coefficients are always less and always opposite in sign to the corrected hydrostatic coefficients.

Discussion. Mr. HERSEY asked whether the change of resistance on stretching was permanent. Mr. SWANN asked whether any measurements had been made in the plane of torsion. Mr. DICKINSON

spoke of the behavior of platinum resistance-thermometers under strain. Mr. BURGESS referred to the possible change of state of copper under pressure. Mr. WHITE spoke of the theoretical considerations involved. Messrs. HERSEY and SWANN considered the application of the recent theory of electrical conduction to the results. Mr. WENNER stated that the temperature coefficient of coils wound under tension at the Bureau of Standards was generally found different from that of the wire before winding; he noted also that the diagram shown by Mr. Adams for copper is very similar to that obtained for silver at the Bureau. The chair expressed to Mr. Adams the thanks of the Society for the interesting communication.

Mr. F. WENNER then reported on a research made in collaboration with Mr. C. F. HANSON in a paper entitled *The experimental basis for Ohm's law*. Some of the experiments which led to the establishment of Ohm's law were discussed and also some of those which were made for the purpose of testing the law. It was pointed out that the experimental tests are not so conclusive as has generally been supposed and that consequently a further consideration of the matter is desirable. Using one of the methods devised by Maxwell, results concordant to about 1 part in 10^6 were obtained—about five times the accuracy obtained by Chrystal working under Maxwell's direction. A new method was devised, making use of a combination of a direct and two alternating currents, one with a frequency nearly but not exactly twice that of the other. The maximum value of the resulting, rapidly pulsating current changes in a slow cycle between definite limits, while the average and root mean square values may remain constant. The changing of the maximum value of the current independent of the average value would give changes in the average value of the potential drop, unless the potential drop were strictly proportional to the current; while keeping the root mean square value of the current constant eliminates the disturbances which would result from a slow cyclic change in the heating. Only preliminary measurements have been made, but these give results concordant to about 1 part in 10^8. In no case has a definite departure from proportionality between current and potential drop been observed.

The 779th meeting was held on November 25, 1916, at the Cosmos Club. President BRIGGS in the chair; 38 persons present. The minutes of the 778th meeting were read in abstract and approved.

Mr. W. P. WHITE gave a paper, illustrated with lantern slides, on *Specific heats at high temperatures*. Platinum and certain silicon compounds were investigated. The charges were heated, usually in electric heaters, and dropped into water in a calorimeter, so that the heat determination was made at ordinary temperatures under favorable conditions. The high temperature measurements in the furnace, the most critical part of the determinations, were made quite satisfactorily, first, by means of regulators which held the furnace temperature constant; second, by measuring temperature at the center of the charge

and by keeping the furnace temperature reasonably uniform by means of platinum-faced partitions and a suitable arrangement of the furnace winding. Duplicate results seldom differed as much as 0.001. Systematic errors in calorimetry are usually much larger than the accidental, but numerous and varied intercomparisons seem to indicate that in this case there were few errors of any sort greater than 0.0015. The specific heats at high temperatures show in general a curvature concave to the x-axis, which is merely the upper part of an S-shaped curve characteristic of these as of all substances and explainable on the basis of the quantum hypothesis. Accepting that explanation, these curves show that the silica and silicon compounds investigated have atomic vibration periods of high frequencies comparable with those characteristic of the atoms of the diamond, whose specific heat curve is similar. These vibration frequencies are due to the oxygen in the compounds and are characteristic of oxygen compounds generally. Platinum shows an altogether different curvature at ordinary temperatures. The relation between the specific heats of the various substances when crystalline and when in the form of glass showed marked differences. There was also a tendency for the specific heat of the glass to increase 10 per cent or more at some rather high temperature; this as yet remains unexplained. Two definite kinds of inversion or transformation in the solid state were demonstrated, characterized by the presence in one case and the absence in the other of large variations in the specific heat below and at the temperature of inversion.

Discussion. Mr. SWANN noted that the agreement of the specific heats fitted in well with the quantum theory. Mr. SOSMAN referred to the different slopes of the heat curves for polymorphic substances and cited in particular the three forms of quartz; the question whether the cause is of atomic or molecular nature is an open one. Mr. L. J. BRIGGS spoke of the atomic heat of platinum at the higher temperatures.

Mr. N. S. OSBORNE then presented an illustrated communication on *A calorimeter for the determination of latent and specific heats of fluids.* The principle of the unstirred or "aneroid" type of calorimeter has been embodied in an instrument especially designed for determinations of the specific heat and latent heat of vaporization of several substances in general use as refrigerating media. Heat developed electrically in a coil located in the central axis of the cylindrical shell comprising the calorimeter is distributed by conduction to the calorimeter and contents whose initial and final temperatures are measured, when in thermal equilibrium, by a platinum resistance thermometer. Heat from other sources is excluded by enveloping the calorimeter with a metal jacket, separated by an air space, and keeping this jacket during measurements at the same temperature as the calorimeter surface, using multiple thermocouples to indicate this equality. The measured heat added is used either to change the temperature of the contents or to evaporate a portion of the contents withdrawn as superheated

vapor; in the first case the specific heat is determined and in the second the latent heat of vaporization, when proper corrections are made. The unique features of this instrument are:

1. Central location of the heater and thermometer,
2. Distribution of metal connections between calorimeter and jacket to minimize errors from lead conduction.
3. Provision of a device for rapid cooling of the calorimeter. This consists of a copper ring which can be moved within the jacket so as to short-circuit thermally the insulating air space and permit the escape of heat to the cooled jacket.
4. Surface temperature equalizer for rendering the annulment of thermal leakage independent of thermal irregularities in the interior of the calorimeter. Measurements were made in the range of temperature from $-40°C.$ to $+40°C.$ of (a) the specific heat of liquid ammonia by two methods, one under saturation conditions, the other at constant pressure; (b) the latent heat of vaporization of ammonia; and (c) the latent heat of compression of liquid ammonia.

Discussion. Mr. White thought the aneroid calorimeter a great advance in calorimetry. He discussed also the relative advantages of large and small calorimeters; a small instrument is to be preferred, provided proper care be used in the details of construction. Mr. Swann spoke of some experiences indicating the advantage of the aneroid type of instrument over the stirred-liquid type.

Informal communications. Mr. M. D. Hersey presented as an informal communication a list of theorems relative to the errors of physical measurements, which he has gradually developed during the past six years as a by-product of other work. There are five theorems relating to apparatus, two to observations, and seven to computations. The manuscript notes, such as they are, are available to any individual interested. Fragments of this work already published are to be found in the Journ. Wash. Acad. Sci., **1**: 187, 1911; **3**: 296, 1913; **6**: 620, 1916; and in the B. A. Rep., Birmingham, 399, 1913.

Mr. White spoke informally on the swelling and splitting, because of amalgamation by mercury, of the platinum element of a thermostat that had been stored away for two or three years. Mr. Wenner remarked that he had many times noted similar effects.

Mr. Humphreys read a humorous poem giving a soldier's opinion of the climate of the Rio Grande.

The 46th annual meeting (780th regular meeting) was held on December 9, 1916 in the assembly hall of the Cosmos Club. President Briggs and President-elect Buckingham in the chair; 34 persons present. The minutes of the 45th annual meeting were read.

The report of the Secretaries was read by Mr. Agnew. Three members, viz., Messrs. Cleveland Abbe, Henry H. Bates, and F. B. McGuire, died during the year; 14 new members were elected; 8 members were transferred to the absent list; 2 members resigned; and 1 member was dropped. The present active membership is 149.

Sixteen regular meetings have been held. In accordance with the recommendation made at the 45th annual meeting, the General Committee amended the By-Laws of the Committee by establishing a class of life membership to include all members who have maintained an active membership in the Society for 40 years. Messrs. CLEVELAND ABBE, F. W. CLARKE, WM. H. DALL, and G. K. GILBERT became life members under this amendment. The report was ordered accepted and placed on file.

The Treasurer's report through December 6, 1916, was read by Mr. SOSMAN. The total receipts for the year, including cash balance of $109.72, were $3,234.83; the total expenditures for the year were $2,791.17; cash balance on December 6, 1916, $443.66. The total par value of the investments now held by the Society is $12,000. The report of the Auditing Committee consisting of Messrs. MUELLER, STILLMAN, and HOSTETTER was read by Mr. MUELLER. This Committee reported the statements in the Treasurer's report had been found correct. The report was ordered accepted. The Treasurer's report was then ordered accepted and placed on file.

Messrs. FERNER and ROTHERMEL were appointed tellers. The following officers were duly elected for the ensuing year: *President:* E. BUCKINGHAM; *Vice-Presidents:* G. K. BURGESS, W. J. HUMPHREYS, R. B. SOSMAN, WM. BOWIE; *Treasurer:* E. F. MUELLER; *Secretaries:* P. G. AGNEW, D. H. SWEET; *General Committee:* H. L. CURTIS, N. E. DORSEY, R. L. FARIS, E. G. FISCHER, J. A. FLEMING, D. L. HAZARD, W. F. G. SWANN, W. P. WHITE, F. E. WRIGHT.

An unanimous vote of thanks was extended to the retiring Treasurer and Secretary for their efficient services to the Society. The rough minutes of the meeting were read and approved.

J. A. FLEMING, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 558th meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday, October 21, 1916; called to order at 8.15 by President HAY with 50 persons in attendance.

The President announced the death of Prof. F. E. L. BEAL, a member of the Society distinguished for his work in economic ornithology.

On recommendation of the Council Mrs. ELLA M. ENLOWS was elected to active membership.

Under the heading Brief Notes and Exhibition of Specimens the following informal communications were presented.

Mr. A. L. QUAINTANCE called attention to a new peach pest related to the codling moth, lately found in the District of Columbia and immediate vicinity. These remarks were illustrated by lantern views of the insect and its work.

Dr. C. W. STILES commented on zoological nomenclature and gave notice that it was the intention to set aside the rules of strict priority

with reference to *Holothuria* and *Physalia* and to use these terms for the animals to which they are currently applied in the usual text books. Dr. Stiles also commented on recent cases in which trichina had figured in certain lawsuits, and expressed the view that with the purchase of meat products went the requirement that the product should be properly cared for and that in the case of pork this care required cooking before consumption; it was somewhat unfair to hold the seller of trichinous meat entirely responsible.

Dr. L. O. Howard cited an instance in which a cockroach was figuring in a lawsuit. A man was suing a Texas railroad for damages on the ground that typhoid fever had been contracted through his drinking pop which had been contaminated by a cockroach, which had apparently been in the bottle before the man drank the pop purchased on the common carrier.

The regular program consisted of an illustrated lecture by Dr. Paul Bartsch: *Mollusk collecting in the Philippines.* Dr. Bartsch reviewed the work of previous collectors and gave an account of his own collecting expedition, describing the methods and apparatus used. He spoke of mollusks as a source of food for the natives, and of their method of gathering them, and called attention to the variations cf these animals as found on different islands. He showed also the necessity of exact locality determinations on specimens, and discussed the geographic distribution of the Philippine molluscan fauna, pointing out its possible origin from other islands or land masses. The lecture covered not only the land mollusks but the marine forms as well.

The 559th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, November 4, 1916; called to order at 8 p. m. by President Hay with sixty persons present.

On recommendation of the Council the following persons were elected to active membership: William B. Bell, Biological Survey; Francis Harper, Biological Survey; H. E. Anthony, American Museum of Natural History; and A. B. Howell, Covina, California.

The President announced the death of Dr. E. A. Mearns, a member of the Council of the Society and distinguished for his work on birds, mammals, and other branches of natural history.

Under the heading Brief Notes and Exhibition of Specimens, Dr. R. W. Shufeldt exhibited a specimen of the Japanese giant salamander and made some remarks on its habits and habitat.

The regular program consisted of four papers as follows:

R. H. Hutchison: *A review of recent work on the house-fly.* This paper was restricted to a discussion of recent studies on the preoviposition period, the range of flight, and the question of the overwintering of the house-fly. The remarks on the preoviposition period summarized a recent bulletin of the Department of Agriculture on this subject (Bulletin 345). In discussing the range of flight, attention was directed to the fact that up to 1914 the longest recorded flight was 1700 yards. During the season of 1915 experiments were carried out

in a suburban locality near Washington by Max Kisliuk, Jr., under the direction of the writer. In these, several records of from 1800 to 2175 yards were obtained. These were compared with the records obtained by R. H. Parker during the same season at Miles City, Montana; his longest record was 3500 yards. The question of how the house-fly overwinters in this latitude was said to be still undecided. It was pointed out that flies were not killed by the first heavy frost, as has often been stated; and that, in fact, a large percentage revived after several nights' exposure to minimum temperatures of 25° F. They are killed by temperatures of 15°F. Flies were found emerging up to the first week in December, and these late forms were found in heated buildings until the end of January. None were again seen till April 27. Other observations were cited as indicating that flies do not overwinter in the adult state; but, on the other hand, a long series of experiments and observations failed to give any positive evidence that they overwinter in the larval or pupal state.

W. Dwight Pierce: *Recent spread of the cotton boll weevil.* A brief history of the movement of this pest through the United States suggests, from a study of specimens collected in all parts of the infested regions of North America, that there are three lines of dispersion. It seems probable that the boll weevil originated in Guatemala or some other portion of Central America and that the most typical strain migrated northward through the mountains of Mexico into Arizona, where it is now found as a native species on the wild cotton-like plant *Thurberia thespesioides.* The main migration was along the Gulf Coast, through the cultivated cotton regions, into the United States. The third line of dispersion was through Yucatan, across the Gulf, to Cuba. Specimens collected at the three termini of these dispersions appear to be very distinct varieties. That variety which is found on cultivated cotton in the United States is the smallest found and the most variable. The movement of the weevil is controlled by the amount of food supply, which regulates the time and distance of natural movement by winds and floods, and by artificial agencies. The most interesting development of the present year is the extension of the weevil to the northern limits of cotton growth in Oklahoma and Arkansas into central Tennessee, eastward to the Atlantic Ocean south of Savannah, and the infestation of practically all the cotton region of Florida. The only Sea Island cotton section now not infected is that of South Carolina.

E. R. Sasscer: *Remarks on entomological inspection and disinfection of products offered for entry into the United States.* A brief review of the Plant Quarantine Act of 1912 was given, pointing out the principal features of the Act as relating to the control of stock entering the States, and what is required of the broker, the nurseryman, or other party importing plants or plant products. The quarantines relating to insects were referred to, and lantern slides of a number of these quarantined insects and others collected by inspectors were shown. Brief mention was made of the method of examining nursery

stock in the District of Columbia, and it was shown that such stock was divided naturally into (1) commercial material, including plants and plant products received by florists, department stores, and private individuals; and (2) Departmental material, including plants and plant products introduced by the various offices of the Department of Agriculture, more particularly the Office of Foreign Seed and Plant Introduction. Some time was devoted to discussing the new method of disinfecting cotton, and lantern slides were shown exhibiting the plants which are now operating in Boston, Mass., Brooklyn, N. Y., Newark, N. J., and Oakland, Cal.

H. S. Barber: *An outline of the glow-worms of the American family Phongodidae.*

The 560th meeting of the Biological Society of Washington was held in the Assembly Hall of the Cosmos Club, Saturday, November 16, 1916; called to order by President Hay at 8 p.m. with 86 persons in attendance.

On recommendation of the Council, Irwin Hoffmann was elected to active membership.

Under the heading, Brief Notes and Exhibition of Specimens, Dr. O. P. Hay exhibited one of the cervical vertebrae of a deer from a deposit in Florida. He called attention to the fact that the remains of Florida deer have usually been referred to the existing species, *Odocoileus osceola.* A comparison of this vertebra with the corresponding one from recent deer, other than the Florida deer, showed that possibly the extinct Florida deer was a different species from the existing deer. Dr. Hay said that there were no examples of cervical vertebrae of Florida deer for making comparisons, and that until such examples were seen the identification of the extinct deer must remain doubtful.

Under the same heading Dr. Paul Bartsch called attention to a hybrid duck which he had lately seen exposed for sale in the markets. It was a cross between the black mallard and the domestic duck.

The regular program consisted of two papers:

H. Pittier: *Forests of Panama* (Illustrated by lantern slides). Professor Pittier gave first a condensed review of the results to the present date of the botanical part of the biological survey of Panama, undertaken under the auspices of the Smithsonian Institution. Then he showed how the distribution of the main ecological types of vegetation is dependent upon the régime of the winds and of the rainfall. Mixed dicotylous forests cover at least six-tenths of the area of the Isthmus, the rest being occupied by savannas and park-like formations. Rain-forests with evergreen foliage extend over the entire northern watershed and part of Darien on the south side. Other forests of the southern slope belong to the type called monsoon-forest and are characterized by the presence of many species with deciduous foliage. The xerophytic character of the vegetation is more marked in the broken forests of the savanna belt, without however assuming an

extreme degree. The change in the composition of the vegetation with the increase in altitude has been dwelt upon by several travellers and botanical explorers of the Isthmus; it is very gradual but nevertheless very radical. Several genera of trees observed at high altitudes are gregarious; there are, for instance, oak-forests, sub-tropical or even temperate in their general appearance. Lantern slides illustrating types of forest, or of individual trees and flowers, were shown at the conclusion of the lecture.

J. H. Paine: *Scientific photography in the study of insects* (Illustrated by lantern slides).

M. W. Lyon, Jr., *Recording Secretary.*

REPRINT OF NUTRITION LECTURES

A series of four public lectures by Dr. E. F. DuBois, Dr. Graham Lusk, Dr. E. B. Forbes and Dr. Carl Voegtlin, dealing with various phases of human and animal nutrition, was given under the auspices of the Washington Academy of Sciences during April, 1916, at the New National Museum, Washington, D. C. In view of the wide-spread interest in the lectures and the importance of the subject, and in response to numerous requests, the Academy has reprinted in collected form a limited edition of the lectures as published in the JOURNAL. It has seemed desirable also to include, as a fitting introduction to the series, the address of the retiring president of the Chemical Society of Washington, Dr. C. L. Alsberg, which was presented in January, 1916, before a joint meeting of the Chemical Society and the Academy.

Copies of the brochure, substantially bound in flexible cloth covers, may be purchased of the Treasurer, Mr. William Bowie, Coast and Geodetic Survey, Washington, D. C., at fifty cents each (postage included).

LYMAN J. BRIGGS,
Chairman, Committee on Meetings.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, January 6: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

E. BUCKINGHAM and E. D. WILLIAMSON: *The effect of elastic strain on the equilibrium temperature of a solid and its liquid.* 20 minutes each.

J. C. HOSTETTER: *The influence of non-uniform pressure on solubility.*

Thursday, January 11: The Washington Academy of Sciences, at the Cosmos Club, at 8 p. m.

Annual meeting for the reports of officers, etc.

This will be followed at 9 p. m. by a joint meeting with the Chemical Society of Washington. Program:

R. B. SOSMAN: *Address of the retiring President of the Chemical Society—Some problems of the oxides of iron.*

Tuesday, January 16: The Anthropological Society, at the New National Museum, room 44, at 4.30 p. m. Program:

WILLIAM H. BABCOCK: *Certain pre-Columbian notices of the inhabitants of Atlantic Islands.*

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the first and fifteenth days of each month.

CONTENTS

ORIGINAL PAPERS

Page

Physics.—Luminescence measurements. N. E. DORSEY 1
Mineralogy.—Mineralogic notes. ESPER S. LARSEN and GEORGE STEIGER.. 6

ABSTRACTS

Geophysics 12
Physics 13
Magnetism 14
Geology 14
Engineering 15
Technology 16

PROCEEDINGS

The Philosophical Society 17
The Biological Society 24

VOL. VII | JANUARY 19, 1917 | No. 2

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY
BY THE
WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

Manuscripts may be sent to any member of the Board of Editors; they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. VII JANUARY 19, 1917 No. 2

MINERALOGY.—*Magnesioludwigite, a new mineral.*[1] B. S. BUTLER and W. T. SCHALLER, Geological Survey.

Introduction. In 1912, while making a reconnaissance examination of the Big and Little Cottonwood districts, Utah, one of the writers, B. S. Butler, collected specimens of the rather rare mineral ludwigite.[2] Specimens of this mineral from the Little Cottonwood district, in an undescribed collection made by J. M. Boutwell, were later examined.

During the summer of 1916 it was possible to make more detailed observations of the occurrence of the mineral, and chemical analysis has shown the presence of an allied mineral, hitherto undescribed, for which the name *magnesioludwigite* is proposed.

Locality. The largest body of ludwigite observed is at the Mountain Lake mine at the head of Big Cottonwood Canyon, about 1¼ miles south of Brighton. Ludwigite occurs in places to the southwest of the Mountain Lake mine for more than half a mile, nearly to Lake Catherine, and also to the east. It was collected on the south side of Little Cottonwood Canyon, southeast of the Michigan-Utah boarding house. It was observed

[1] Preliminary paper. Published with the permission of the Director of the U. S. Geological Survey.

[2] BUTLER, B. S., and LOUGHLIN, G. F. *A reconnaissance of the Cottonwood-American Fork mining region, Utah.* U. S. Geol. Survey Bull. 620, p. 201. 1915.

in rock débris near the Alta-Brighton trail north of Twin Lakes. and is abundant in the South Columbus tunnel of the South Hecla mine. It will doubtless be found at other localities in the district. Magnesioludwigite was found only in the Mountain Lake mine.

Occurrence. Ludwigite occurs as a replacement of limestone at or near the contact with intrusive rocks and is associated with "contact minerals," including magnetite, forsterite, garnet, diopside, muscovite, and sulphides of iron and copper. In the Mountain Lake deposit magnetite and forsterite are the most abundant original minerals associated with the ludwigite. All of the minerals were probably formed at the same time, though the presence of veinlets of magnetite in the ludwigite and in the forsterite indicates that the magnetite continued to form after the ludwigite and forsterite had ceased to form. The sulphides also, in part at least, were formed probably later than the ludwigite and forsterite.

In the Mountain Lake deposit the ludwigite is in finely fibrous crystals, forming radial and spherulitic groups which make up large masses of the mineral. These, as seen with the unaided eye or the hand lens, resemble tourmaline. There are exposed in the outcrop and on the dump many tons of a mixture of magnetite and ludwigite. The ludwigite occurs also as isolated crystals and groups of crystals in metamorphosed limestone, and from such occurrences well-defined crystals with natural crystal faces have been isolated and measured. The ludwigite is dull greenish black (Ridgway's color scale). In the outcrop of the deposit there is also much material of ivy-green color (Ridgway's color scale), which is the mineral for which the name magnesioludwigite is proposed. Its occurrence is like that of the ludwigite.

Composition. Chemical analysis has shown that only 2.55 per cent of ferrous oxide is present in the ivy-green mineral, whereas typical ludwigite contains 17.01 per cent ferrous oxide. The analysis has also determined that the formula of the new mineral is $MgO.Fe_2O_3.3MgO.B_2O_3$, in which a small amount of ferrous oxide replaces some of the magnesia. The analysis

can be interpreted as representing an isomorphous mixture of 85 per cent of magnesium borate with 15 per cent of ferrous borate. In its various properties magnesioludwigite shows the expected differences from those of the iron-richer ludwigite from Hungary. The luster is duller, the color lighter, the pleochroism and absorption weaker, and the translucency of the crushed material is markedly greater.

These various changes in properties are correlated with the changes in chemical composition, and the existence of a definite series from the ferrous-iron borate to the magnesium borate is well shown by specimens of the mineral from Hungary, Montana, and Utah. This correlation is being made and will be given in full in the detailed paper now in preparation.

The increased knowledge of the variation in chemical composition and corresponding variations in other properties makes it necessary to recognize the two end members of the series of the natural magnesium-iron borates. It is therefore proposed to use the name ludwigite as a group name, similarly to the usage of the terms mica and feldspar, and to introduce the two names magnesioludwigite and ferroludwigite for the end members and for those parts of the series in which the magnesium or the ferrous-iron borate, respectively, predominates.

Including the mineral pinakiolite in the group, the ludwigite group comprises then the following minerals, the term ludwigite being usable for any member of the group until its exact relation has been determined:

- Group
  - Ludwigite
    - Species
      - Ferroludwigite, $FeO.Fe_2O_3.3MgO.B_2O_3$
      - Magnesioludwigite, $MgO.Fe_2O_3.3MgO.B_2O_3$
      - Pinakiolite, $MnO.Mn_2O_3.3MgO.B_2O_3$.

ANTHROPOLOGY.—*Significance of the terms for brother and sister among primitive peoples.* JOHN R. SWANTON, Bureau of American Ethnology.

It is well known that among tribes divided into clans or gentes the terms for those relations for which we use "brother"

and "sister" are extended to a large number of individuals of the same clan or gens and of approximately the same age as the speaker, but even experienced investigators are not so vividly conscious of the fact that they are by no means confined to that clan or gens. The idea of such a limitation is largely due to the fact that very many tribes, such for instance as the Iroquois, Choctaw, Chickasaw, Tlingit, Haida, and several of the Plains tribes, have only two exogamous groups, and that in such groups the men called collectively "fathers" are the husbands of the women called collectively "mothers." It happens, therefore, that the children of the father's brothers and the mother's sisters are the very same set of individuals and must always be of the exogamous division of the speaker and his own brothers and sisters. Thus it might be thought that the terms brother and sister were applied because the individuals so called were of the same clan or gens as self.

In order to discover the true reason for the application of these terms we must turn to tribes having three or more exogamous groups. Among peoples of this kind with matrilineal descent the men of the father's clan will be able to marry into two or more others and their children will be of the same number of clans, while if the descent is patrilineal the women of the mother's clan will have the same variety of choice. Now, if the terms for brother and sister are primarily clan or gentile terms, they will not be applied to children of the father's clan or the mother's gens *not of the clan or gens of the speaker*. If they are primarily consanguineal terms they will be so applied.

In the present article I shall not attempt an exhaustive study of this question but confine myself to an examination of the lists given by Morgan in his *Systems of Consanguinity and Affinity*[1] and those recorded by Rivers in *The History of Melanesian Society*. The internal diversity of the two regions, each of which presents examples of tribes with exogamous divisions and tribes without, tribes with matrilineal descent and tribes with patrilineal descent, tribes with dual divisions and tribes with multiple divisions, along with their remoteness from

[1] Smithsonian Contributions to Knowledge, vol. 17.

each other, and the difference in time and circumstance under which they were recorded, promises a very fair sample of what may be looked for in primitive society as a whole.

An inspection of the lists given by Morgan shows that the terms for brother and sister—elder and younger being also frequently distinguished—are employed by all tribes from which information is supplied except the Eskimo, who are without exogamous groups and therefore do not concern us. It is true that among certain peoples, such as the Chippewa, Ottawa, Potawatomi, Mohegan, Delaware, Spokane, and Creek, a distinction is introduced between the own brother and sister and collateral brothers and sisters, who are often called "step-brothers," "step-sisters," "other brothers," and so on; but we find that in most cases these exceptional terms apply to both the child of the father's brother and the child of the mother's sister; therefore their significance is mainly consanguineal and their use strengthens rather than weakens the argument for consanguinity. In one or two other cases the terms used are alternatives. Rivers yields precisely the same testimony. In his explanation of the terms employed in the island of Florida he specifically states that those for brother and sister were used "in the usual classificatory sense for all members of the clan of the same generation" and that they were applied also "in the same way to the children of the father's brothers, although these may be of different clans." By implication the same must be assumed in the systems recorded by him from the Torres Islands, Santa Cruz, the Reef Islands, Guadalcanar, Ysabel, and Savo, all of those in which there are more than two exogamous divisions and from which information is vouchsafed. The same is found, as we should expect, in tribes having two exogamous groups, and also in tribes without exogamous groups. In some cases these terms are so widely extended as to apply to the cross-cousins as well, the children of the father's sister and the mother's brother. The outstanding fact is, however, that the application of the terms for brother and sister is evidently governed by the relation of the parents of the persons so called to self.

Precisely the same thing appears in the succeeding generation, where the use of the terms son and daughter, and nephew and niece, is plainly determined by the status of the parents of those so denominated.

These facts may be illustrated by the accompanying diagram, in which it is to be understood that each English expression stands for a single native term. It supposes a tribe with several clans and matrilineal descent, self male. Other systems would involve a few simple and readily comprehended changes.

DIAGRAM ILLUSTRATING "BROTHER" AND "SISTER" RELATIONSHIPS.

father's brothers' wives (clans 1, 3, 4, etc.) =	father's brothers (clan 2)		father (clan 2) = mother (clan 1)		mother's sisters (clan 1) =	mother's sisters' husbands (clans 2, 3, 4, etc.)
brothers (clans 1, 3,4,etc.)	sisters (clans 1, 3,4,etc.)	brothers (clan 1)	self male (clan 1)	sisters (clan 1)	brothers (clan 1)	sisters (clan 1)
sons and daughters (clans 1, 2, 3, 4, etc.)	nephews and nieces (clans 1, 2, 3,4,etc.)	sons and daughters (clans 2, 3, 4, etc.)	sons and daughters (clans 2, 3, 4, etc.)	nephews and nieces (clan 1)	sons and daughters (clans 2, 3, 4, etc.)	nephews and nieces (clan 1)

An examination of the remaining terms of relationship shows that almost the only ones which have a strictly clan or gentile connotation are those for father, mother, father's sister, and mother's brother. Those who argue for the priority of exogamous divisions to relationship terminology and for their clan rather than consanguineal significance are therefore reduced to the assumption that such divisions first determined the four terms last given and that all of the others were developed from them on purely consanguineal lines. But even in the case of these four terms we ordinarily find a distinction between the own father and mother and the clan or gentile father and mother, and frequently there are other exceptions to a strictly

clan usage of the terms. A theory which has to admit so many exceptions and which must grant the dominance of consanguineal considerations in all but a few cases may well be viewed with suspicion. It is certainly a clumsy device when compared with the alternative theory of a simple extension of terms founded on the idea of blood relationship to groups of persons hypothetically, though not actually, related.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*A study of electromagnet moving coil galvanometers for use in alternating current measurements.* Ernest Weibel. Bureau of Standards Scientific Paper No. 297 (Bull. Bur. Stds., **14**: 23-58). 1917.

This paper gives the results of a study of the electromagnet moving coil galvanometer that has led to the construction of instruments with sensitivities much greater than those previously obtained and equal to those of the best direct current moving coil galvanometers. The theory of the instrument is developed. The equation of motion is first expressed in terms of the intrinsic constants (the moment of inertia, the moment of damping, the moment of restoration, and the moment of displacement) and the deflection, velocity, acceleration, and current in the moving coil. The current is then known from the resultant electromotive force in the moving coil circuit and the latter's constants. It is necessary in computing the resultant electromotive force to consider not only the impressed but also the induced electromotive force. The latter is in part due to the motion of the coil in the magnetic field, causing electromagnetic damping, and in part due to the alternation of the flux linking with the coil, causing a current which results in a control torque in addition to that of the suspensions. The paper also contains descriptions and gives the performances of four instruments. The results indicate that the theory as given is fundamentally correct and therefore serves as a good basis for the design and use of instruments of this kind. E. W.

GEOLOGY.—*The lignite field of northwestern South Dakota.* Dean E. Winchester, C. J. Hares, E. Russell Lloyd, and E. M. Parks. U. S. Geological Survey Bulletin 627. Pp. 165, with 11 plates. 1916.

The report describes the geology and fuel resources of parts of Perkins and Harding counties in northwestern South Dakota. The

formations in the area include the Pierre, Fox Hills, Lance, Fort Union, White River, and Arikaree. The Lance is subdivided into three members: a lower undifferentiated portion, 425 feet thick; a middle or Ludlow lignite-bearing portion, 350 feet thick at most; and an upper marine member, the Cannonball, 225 feet thick.

The marine fauna of the Cannonball member is very similar to but not identical with the fauna of the Fox Hills, which is of recognized Cretaceous age, while the flora of the Ludlow lignitic member is so much like that of the Fort Union, which is of recognized Tertiary age, that it is impossible to differentiate it from the Fort Union on the basis of the fossil leaves.

Lignite beds are found in both the Lance and Fort Union formations, the more important beds occurring in the Lance formation.

D. E. W.

GEOLOGY.—*Reconnaissance of the Conconully and Ruby mining districts, Washington.* E. L. JONES, JR. U. S. Geological Survey Bulletin 640-B. Pp. i–iv, 11–36, with 1 plate. 1916.

This report describes the geology and ore deposits of a small area in the central part of Okanogan County, Washington. In general the rocks comprise an older series of metamorphic rocks and a younger series of igneous rocks of batholithic origin. The metamorphic rocks consist of schists, quartzites, and limestones. Some of the schists are fine-grained and thinly laminated, but others are coarsely banded micaceous rocks that are evidently altered sandstones. The most schistose and gneissoid rocks are those which border the batholith. Closely associated with this sedimentary series are dike rocks and lavas that have undergone the same metamorphism and are probably of the same age, which is supposed to be Carboniferous.

The common igneous rock of the area is a gray granite which has intruded the sedimentary rocks. It occurs over a large area and is probably a part of the Similkameen batholith. There are other igneous rocks of considerable areal extent, including a dark granite and an altered green porphyry. Dikes are abundant, particularly along the contact of the batholith with the metamorphic rocks; they include granite, diorite, pegmatite, and aplite, and probably represent the closing stage of igneous activity.

The ore deposits are principally of two types, quartz veins and disseminated or replacement deposits. The quartz veins are widely distributed throughout the area, but those of proved value are grouped

along the contact of the granite with the schists and gneisses. They are valuable for their lead-silver content and have yielded the principal output. The replacement deposits occur principally in a small area at the northern end of the Conconully district. They contain small amounts of copper and gold, but no ore has yet been produced commercially from them. R. W. S.

GEOLOGY.—*A reconnaissance of the Archean complex of the Granite Gorge, Grand Canyon, Arizona.* L. F. Noble and J. Fred. Hunter. U. S. Geological Survey Professional Paper No. 98-I. Pp. 95–102, with 1 plate and 2 figures. 1916.

The Tonto platform on the south side of the Granite Gorge affords a magnificent but difficultly accessible cross-section through the Archean complex, 800 feet deep and 40 miles in length. These oldest rocks of the Grand Canyon were visited in twenty localities, 67 hand specimens were collected, and eight distinct groups of rocks were recognized. The exposures within these groups are described and the petrography of the specimens is given.

Estimated roughly, the gneisses (granite gneiss, hornblende gneiss, and metabasite) comprise 50 per cent of the rock exposed in the Granite Gorge; the mica schist, 30 per cent; the basic intrusives, 10 per cent; and the pink siliceous intrusives, 10 per cent. It is not improbable that the mica schists are in large part of sedimentary origin. It is believed that some of the wrinkled and contorted granite gneisses represent the original basement on which the schist series of metamorphosed sediments was laid down; that both before and after the deposition of the sediments there were long periods of complex intrusion, represented by amphibolites, granitic gneiss, metabasite, and metadiorite; that during and after the metamorphism of the schists and gneisses there were further intrusions of quartz diorite, gabbro, granite, pegmatite, and other rocks. It will probably be advisable, at some future time, to restrict the name "Vishnu schists," now used for the entire Archean complex, to the mica-schist series and give another name or names to the gneisses. J. F. H.

GEOLOGY.—*An anticlinal fold near Billings, Noble County, Oklahoma.* A. E. Fath. U. S. Geological Survey Bulletin 641–E. Pp. 121–138, with 1 plate. 1916.

During February, 1916, gas was struck in small quantities at shallow depths in a well being drilled a few miles southwest of Billings, Noble

County, Oklahoma. As this discovery was made at a place more than 20 miles distant from any other known oil and gas development, it has attracted considerable attention, which is justified by the presence of a large anticlinal fold, a type of structure that should be favorable for the accumulation of oil and gas. A description of the anticlinal fold and a discussion of the possibilities of developing an oil and gas field here are given. R. W. S.

PALEONTOLOGY.—*North American Upper Cretaceous corals of the genus Micrabacia.* LLOYD WILLIAM STEPHENSON. U. S. Geological Survey Professional Paper 98-J. Pp. 115–131, with 4 plates. 1916.

The report describes seven species and two varieties of corals of the genus *Micrabacia* from the United States, all but one of which, *M. americana* Meek and Hayden, are new. All are from the Atlantic and Gulf coastal plains, except *M. americana* and its variety *multicostata* from the Montana group of the Western Interior. Of the coastal-plain species, *M. cribraria* is from the upper part of the *Exogyra ponderosa* zone (North Carolina—Alabama), and the remainder are from the *Exogyra costata* zone of Maryland, Georgia, Mississippi, and Texas. The American species are compared with the type species of the genus, *M. coronula* Goldfuss, a description and figures of which are included, from Essen, Prussia. Each of the species has a small disc-shaped corallum, the largest, *M. rotatilis*, being only 9 mm. in diameter; in order to illustrate the characters it is necessary to magnify them four to eight times. L. W. S.

TECHNOLOGY.—*The recovery of paraffin and paper stock from waste paraffin paper.* W. H. SMITH. Bureau of Standards Technologic Paper No. 87. Pp. 4. 1916.

This paper describes a process for the recovery of the paraffin and paper stock from waste paraffin paper. The waste is pulped with exhaust steam in a vertical boiler. The wax rises to the surface and is drawn off with the hot water through a screen, the stock settling to the bottom of the boiler. The stock is transferred to a beating engine and further treated for the removal of the residual paraffin. Paper prepared from the recovered stock was free from wax and satisfactory in every respect. Practically all of the paper stock is recovered, but about ten per cent of the paraffin in the waste is lost during the process. W. H. S.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to all scientific papers published in or emanating from Washington. It is requested that authors cooperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

CHEMISTRY

BLUM, WILLIAM. *The determination of aluminium as oxide.* Bureau of Standards Scientific Paper No. 286 (Bull. Bur. Stds., **13**: 515–534). 1916.

CAIN, J. R., SCHRAMM, E., and CLEAVES, H. E. *The preparation of pure iron and iron-carbon alloys.* Bureau of Standards Scientific Paper No. 266 (Bull. Bur. Stds., **13**: 1–26). 1916.

CLARKE, F. W., and WHEELER, W. C. *The inorganic constituents of alcyonaria.* Proc. National Acad. Sci., **1**: 552–556. 1915.

GILLESPIE, L. J. *The reaction of soil and the measurements of hydrogen-ion concentration.* Journ. Wash. Acad. Sci., **6**: 7–16. 1916.

HILLEBRAND, W. F., and SCHERRER, J. A. *Recovery of gallium from spelter in the United States.* Journ. Ind. and Eng. Chem., **8**: 225. 1916.

LUBS, HERBERT A., and CLARK, MANSFIELD. *On some new indicators for the colorimetric determination of hydrogen-ion concentration.* Journ. Wash. Acad. Sci., **5**: 609–617. 1915.

WATERS, C. E., and TUTTLE, J. B. *Some qualitative tests for gum arabic and its quantitative determination.* Bureau of Standards Technologic Paper No. 67. Pp. 15. 1916.

WEAVER, E. R. *The colorimetric determination of acetylene and its application to the determination of water.* Bureau of Standards Scientific Paper No. 267 (Bull. Bur. Stds., **13**: 27–65). 1916.

MAMMALOGY

ALLEN, J. A. *The genotypes of Echimys and Loncheres.* Proceedings of the Biological Society of Washington, **29**: 205–206. September 22, 1916. (Argues that *E. spinosus* is the type of Echimys and *L. chrysurus* the type of Loncheres.—N. H.)

GABRIELSON, I. N. *A second record of* Nyctinomus depressus *for Iowa.* Proceedings of the Biological Society of Washington, **29**: 86. April 4, 1916. (A specimen of this southwestern species taken at Marshalltown.—N. H.)

GOLDMAN, E. A. *Notes on the genera* Isothrix *Wagner and* Phyllomys *Lund.* Proceedings of the Biological Society of Washington, **29**: 125–126. June 6, 1916. (Several species heretofore included in Isothrix are transferred to the genus Phyllomys.—N. H.)

GOLDMAN, E. A. *The status of* Sigmodontomys alfari *Allen and* Oryzomys ochraceus *Allen.* Proceedings of the Biological Society of Washington, **29**: 127. June 6, 1916. (These specific names are synonymous, and the animal should be called *Nectomys alfari*.—N. H.)

GOLDMAN, E. A. *A new vesper rat from Nicaragua.* Proceedings of the Biological Society of Washington, **29**: 155–156. September 6, 1916. (Describes *Nyctomys sumichrasti venustulus* from Greytown.—N. H.)

GRINNELL, J. *The California lowland mink a distinct race.* Proceedings of the Biological Society of Washington, **29**: 213–214. September 22, 1916. (Describes *Mustela vison aestuarina* from Solano County.—N. H.)

HOLLISTER, N. *Descriptions of a new genus and eight new species and subspecies of African mammals.* Smithsonian Miscellaneous Collections, **66**[1]: 1–8. February 10, 1916. (Cercoctenus, new genus of Macroscelidae; and new forms in the genera Surdisorex, Rhinolophus, Eptesicus, Chaerephon, Genetta, Mungos, and Helogale.—N. H.)

HOLLISTER, N. *Three new African shrews of the genus Crocidura.* Smithsonian Miscellaneous Collections, **66**[2]: 1–3. May, 1916. (*C. daphnia* described from Uganda; *C. parvipes nisa* and *C. simiolus* described from British East Africa.—N. H.)

HOLLISTER, N. *The generic names Epimys and Rattus.* Proceedings of the Biological Society of Washington, **29**: 126. June 6, 1916. (Rattus the proper generic name for the Norway rat and its allies.—N. H.)

HOLLISTER, N. *A systematic account of the prairie-dogs.* North American Fauna No. 40. Pp. 1–37, pls. 1–7. June 20, 1916. (New subgenus, Leucocrossuromys, for the white-tailed prairie-dogs; new subspecies *Cynomys gunnisoni zuniensis*, from New Mexico.—N. H.)

HOLLISTER, N. *The type species of Rattus.* Proceedings of the Biological Society of Washington, **29**: 206–207. September 22, 1916. (*Mus norvegicus* is the type of *Rattus* Fischer, 1803.—N. H.)

HOLLISTER, N. *Shrews collected by the Congo expedition of the American Museum.* Bulletin of the American Museum of Natural History, **35**: 663–680, pls. 7–11. October 21, 1916. (Six new species of Crocidura and one of Sylvisorex from Belgian Congo.—N. H.)

HOLLISTER, N. *Three new murine rodents from Africa.* Smithsonian Miscellaneous Collections, **66**[10]: 1–3. October 26, 1916. (Describes new forms of Arvicanthis, Dasymys, and Mus.—N. H.)

HOWELL, A. H. *Description of a new pine mouse from Florida.* Proceedings of the Biological Society of Washington, **29**: 83–84. April 4, 1916. (*Pitymys parvulus*, sp. nov., from Ocala.—N. H.)

JACKSON, H. H. T. *A new bat from Porto Rico.* Proceedings of the Biological Society of Washington, **29**: 37–38. February 24, 1916. (Describes *Eptesicus wetmorei* from Maricao.—N. H.)

LANTZ, D. E. *Cottontail rabbits in relation to trees and farm crops.* U. S. Department of Agriculture Farmers' Bulletin No. 702. Pp. 1–12, figs. 1–5. January 17, 1916. (Discusses the habits of cottontail rabbits and methods of controlling their numbers.—N. H.)

LANTZ, D. E. *Laws relating to fur-bearing animals, 1916.* United States Department of Agriculture Farmers' Bulletin No. 783. Pp. 1–28. October 19, 1916. (A summary of laws in the United States and Canada relating to fur-bearing animals.—N. H.)

LYON, M. W., JR. *A porcupine skull with a pair of supernumerary well developed incisors in the upper jaw.* Anatomical Record, **10**: 459–462. April 20, 1916. (Note on abnormal dentition of *Acanthion longicaudum.*—N. H.)

LYON, M. W., JR. *Belgian hare, a misleading misnomer.* Science, N. S., **43**: 686. May 12, 1916. (Corrects error in generic identification of the Belgian "hare" in anatomical paper by C. D. Holliger.—N. H.)

LYON, M. W., JR. *Two new mammals from Sumatra.* Proceedings of the Biological Society of Washington, **29**: 209–211. September 22, 1916. (Describes new forms of Rattus.—N. H.)

MERRIAM, C. H. *East Africa—Game garden of the world.* American Museum Journal, **16**: 145–153. March, 1916. (A review of Roosevelt and Heller's "Life-Histories of African Game Animals," 1914.—N. H.)

MERRIAM, C. H. Ovis sheldoni, *a new mountain sheep from Sierra del Rosario, Sonora, Mexico.* Proceedings of the Biological Society of Washington, **29**: 129–132. September 6, 1916.

MERRIAM, C. H. *Nineteen apparently new grizzly and brown bears from western America.* Proceedings of the Biological Society of Washington, **29**: 133–154. September 6, 1916. (Descriptions of new species and subspecies of Ursus, with remarks on distribution and relationship of mainland and island forms.—N. H.)

MILLER, G. S., JR. *Note on the indigenous rodent of Santo Domingo.* Proceedings of the Biological Society of Washington, **29**: 47. February 24, 1916. (Records additional specimens of *Plagiodontia aedium* Cuvier, hitherto known only by the type described in 1836.—N. H.)

MILLER, G. S., JR. *Remains of two species of Capromys from ancient burial sites in Jamaica.* Proceedings of the Biological Society of Washington, **29**: 48. February 24, 1916. (A species apparently much like the form known from Little Swan Island is represented by bones; as well as remains of the previously known Jamaica species, *C. brownii.*—N. H.)

NELSON, E. W. *The larger North American mammals.* National Geographic Magazine, **30**: 385–472. November, 1916. (A popular account, illustrated by numerous colored pictures by L. A. Fuertes.—N. H.)

TAYLOR, W. P. Aplodontia humboldtiana, *a new mountain beaver from the Humboldt Bay district, California.* Proceedings of the Biological Society of Washington, **29**: 21–23. February 24, 1916.

THOMAS, O. *Note on the name* Corynorhinus megalotis. Proceedings of the Biological Society of Washington, **29**: 127. June 6, 1916. (Preoccupied; replaced by *Corynorhinus rafinesquii.*—N. H.)

TECHNOLOGY

AHLBORN, G. H. *Data on electric railway track leakage.* Bureau of Standards Technologic Paper No. 75. Pp. 22. 1916.

BOUGHTON, E. W. *The determination of volatile thinner in oil varnish.* Bureau of Standards Technologic Paper No. 76. Pp. 6. 1916.

BRIGGS, C. A. *Relative merits of long and short wheel-base test cars.* The Scale Journ., **1**: 5. 1915; Railway Rev., Aug. 14, 1915; Railway Age Gaz., April 21, 1916.

BRIGGS, C. A. *Automatic grain scales.* Scale Journ., Jan. and May, 1916.

BRIGGS, C. A. *Graphical study of railroad track scales and master scale performances.* Scale Journ., June. 1916; Railway Rev., July 15, 1916.

BUREAU OF STANDARDS. *Analyzed irons and steels. Methods of analysis.* Bureau of Standards Circular No. 14, 5th ed. Pp. 17. 1916.

BUREAU OF STANDARDS. *Magnetic testing.* Bureau of Standards Circular No. 17, 3d ed. Pp. 50. 1916.

BUREAU OF STANDARDS. *Measurements for the household.* Bureau of Standards Circular No. 55. Pp. 149. 1915.

BURGESS, G. K., and MERICA, P. D. *Some foreign specifications for railway materials: Rails, wheels, axles, tires.* Bureau of Standards Technologic Paper No. 61. Pp. 132. 1916.

CAIN, J. R., and CLEAVES, H. E. *Determination of carbon in steels and irons by direct combustion in oxygen at high temperatures.* Bureau of Standards Technologic Paper No. 69. Pp. 10. 1916.

KARR, C. P., and RAWDON, HENRY S. *Standard test specimens of zinc bronze (Cu 88, Sn 10, Zn 2). Part I.—Preparation of specifications; Part II.—Microstructure.* Bureau of Standards Technologic Paper No. 59. Pp. 67. 1916.

LEWIS, WALTER S. *Difference in weight between raw and clean wools.* Bureau of Standards Technologic Paper No. 57. Pp. 5. 1915.

MCCULLOM, B., and AHLBORN, G. H. *Special studies in electrolysis mitigation. III. A report on conditions in Springfield, Ohio, with insulated feeder system installed.* Bureau of Standards Technologic Paper No. 54. Pp. 64. 1916.

MCCULLOM, B., and LOGAN, K. H. *Special studies in electrolysis mitigation. IV. A preliminary report on electrolysis mitigation in Elyria, Ohio, with recommendations for mitigation.* Bureau of Standards Technologic Paper No. 55. Pp. 49. 1916.

MCCULLOM, B., and AHLBORN, G. H. *Influence of frequency of alternating or infrequently reversed currents on electrolytic corrosion.* Bureau of Standards Technologic Paper No. 72. Pp. 31. 1916.

ROSA, E. B., BROOKS, H. B., MCCULLOM, B., CANADA, W. J., and GLADING, F. W. *An investigation of enclosed cartridge fuses. Report of the Bureau of Standards in the case of Economy Fuse and Manufacturing Co. vs. Underwriters' Laboratories (Inc.), concerning the fire and accident hazard of the Economy Refillable Fuse as compared with approved fuses.* Bureau of Standards Technologic Paper No. 74. Pp. 199. 1916.

TUTTLE, J. B. *Determination of barium carbonate and barium sulphate in vulcanized goods.* Bureau of Standards Technologic Paper No. 64. Pp. 5. 1916; Journ. Ind. and Eng. Chem., **8**: 324. 1916; Chem. Eng., **23**: 129. 1916; Chem. Abs., **10**: 1289. 1916.

WATERS, C. E., and TUTTLE, J. B. *Some qualitative tests for gum arabic and its quantitative determination.* Bureau of Standards Technologic Paper No. 67. Pp. 15. 1916; Journ. Ind. and Eng. Chem., **8**: 413–416. 1916.

WATERS, C. E. *Data on the oxidation of automobile cylinder oils.* Bureau of Standards Technologic Paper No. 73. Pp. 20. 1916; Journ. Ind. and Eng. Chem., **8**: 587–592. 1916.

WIG, R. J., WILLIAMS, G. M., and GATES, E. R. *Strength and other properties of concretes as affected by materials and methods of preparation.* Bureau of Standards Technologic Paper No. 58. Pp. 172. 1916.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The sixteenth annual meeting of the Botanical Society of Washington was held in Room 32 of the Bureau of Plant Industry building, U. S. Department of Agriculture, at 1.30 p.m., October 16, 1916, with W. E. SAFFORD acting chairman and H. L. SHANTZ acting secretary.

The minutes of the fifteenth annual meeting were read and approved and the report of the Executive Committee read and approved. The report of the Treasurer was read and an Auditing Committee, consisting of P. L. RICKER and G. P. VAN ESELTINE, appointed by the Chair.

The following officers were elected for the ensuing year: *President*, T. H. KEARNEY; *Vice-President*, EDGAR L. BROWN; *Recording Secretary*, CHARLES E. CHAMBLISS; *Corresponding Secretary*, H. L. SHANTZ; *Treasurer*, F. D. FARRELL.

Mr. A. S. HITCHCOCK was nominated by the society as Vice-President of the Washington Academy of Sciences.

The 115th regular meeting of the Society was held at the Cosmos Club Tuesday, November 7, 1916, at 8.00 p.m.

Mr. MICHAEL SHAPOVALOV, Dr. HOWARD G. MACMILLAN, Dr. JOSEPH ROSENBAUM, and Mr. F. E. MILLER were elected to membership in the Society.

Under Brief Notes and Reviews of Literature, Mr. W. T. SWINGLE called attention to a recent edition of an ancient Chinese work on botany, *The Cheng lei pen ts'ao*, originally published in 1108 A.D. Dr. A. T. TENAKA reviewed briefly a recently issued *Hand Book of Plant Diseases of Japan*, by Jinzo Matsumura.

The following papers were presented:

Notes on the life of John Bradbury: R. H. TRUE. Information concerning the life of this early naturalist and explorer of the Missouri Valley is very meager. A considerable addition has been gained from the correspondence carried on between Bradbury and Thomas Jefferson, who greatly influenced the course of Bradbury's life and work in this country. Bradbury's life, as gathered from this and other available sources, was sketched in outline.

Pathological problems in the distribution of perishable plant products: C. L. SHEAR and W. A. ORTON. The enormous losses in recent years caused by the deterioration and decay of fruits and vegetables between the field and the consumer have led to a more active interest in this subject and a desire on the part of those most directly affected to have the causes and means of prevention determined. In most cases fungi are the active agents in causing the destruction of such products, and the problem is primarily pathological. In order to devise means of avoiding these losses, a thorough knowledge of all the factors and conditions involved must be obtained. Each fruit and vegetable has its own peculiarities and its own parasites. In some cases the cause of loss may be traced to the field, and in others to conditions of transportation and handling. In any specific case the cause and responsibility for the loss can be determined only by careful investigation of all the facts. Specific cases of losses of strawberries, peaches, cranberries, watermelons, tomatoes, and potatoes were cited to indicate the complexity of the problems and the danger of drawing any general conclusions from insufficient data. It was shown that the means of preventing such losses will depend upon the nature of the cause or causes, as determined by a knowledge of all the factors in any particular case.

H. L. SHANTZ, *Corresponding Secretary.*

BIOLOGICAL SOCIETY OF WASHINGTON

The 561st meeting of the Society was held at the Cosmos Club, Saturday, December 2, 1916; called to order by President HAY at 8 p.m. with 50 persons in attendance.

The following program was presented:

W. P. HAY: *The discovery of an interesting new tardigrade.*

Professor Hay gave a brief description of a tardigrade belonging to the genus *Batillipes*, discovered by him some years ago at Beaufort, N. C. It is closely related to *B. mirus* Richters but differs from that species in a number of important characters. The structure and relationship of the tardigrades were discussed and the conclusion was reached that *Batillipes*, in spite of its evident specialization along certain lines, is probably the most primitive genus of the group. From *Batillipes* through *Halechiniscus* to *Oreella* and *Echiniscus* was suggested as one line of development, while from *Echiniscoides* through *Milnesium* to *Macrobiotus* and *Diphascon* appears to be another. The genus *Tetrakentron*, with its single species *T. synaptae*, shows a high degree of specialization due to parasitism, and *Microlyda* is probably the larval form of *Halechiniscus*.

Attention was called to the habitat of the ten animalcules belonging to these genera. Five of them, *Batillipes*, *Halechiniscus*, *Microlyda*, *Tetrakentron*, and *Echiniscoides* are marine; *Echiniscus* and *Oreella* are strictly terrestrial; *Macrobiotus* is mostly terrestrial or lacustrine, but is represented in salt water by at least two species; *Diphascon* is

terrestrial and lacustrine. The fact that the majority of the genera are marine and that this list includes all the more primitive genera points strongly to a marine origin for the group. It also supports the idea advanced by Professor Richters in 1909 that the tardigrades are probably most closely related to the chaetopod worms and should be removed from the class Arachnida in or near which the group is usually placed in our zoological text books. Professor Hay's communication was illustrated by charts and diagrams.

J. N. ROSE: *Exhibition of Venezuelan plants and fruits.*

Dr. Rose had on exhibition a large tableful of fruits, fruit products, and various articles made of parts of Venezuelan plants. He explained their use and described the plants from which they were obtained. The specimens were obtained for the most part in the vicinity of La Guaira and Caracas. Dr. Rose's communication was discussed by Messrs. H. PITTIER, M. W. LYON, Jr., and others.

M. W. LYON, JR.: *Poisonous snakes.*

Dr. Lyon gave an account of the various specific substances that have been found in snake venoms, and outlined their modes of action on the various tissues of bitten animals. He spoke of the various antiserums that have been prepared against these venoms, and their therapeutic uses. He called attention also to the non-specific treatment of snakebites in the light of modern statistics and experiments. He then gave a brief outline of the classification of venomous snakes, and discussed their geographic distribution and the development and structure of the poison gland and fang. His communication was illustrated by lantern slide views of skulls, glands, and fangs of poisonous snakes, of types of poisonous snakes, and of some of the histological changes caused by snake venom. It was discussed by Messrs. A. A. DOOLITTLE, H. PITTIER, H. M. SMITH, H. E. AMES, and T. E. WILCOX.

The 562d regular and the 37th annual meeting of the Society was held at the Cosmos Club, Saturday, December 16, 1916; called to order by President HAY at 8 p.m. with 23 persons present.

Annual reports of officers and committees were submitted. Election of officers for the year 1917 resulted as follows: *President,* W. P. HAY; *Vice-presidents,* J. N. ROSE, A. D. HOPKINS, HUGH M. SMITH, VERNON BAILEY; *Recording Secretary,* M. W. LYON, JR.; *Corresponding Secretary,* W. L. MCATEE; *Treasurer,* NED DEARBORN; *Members of Council,* N. HOLLISTER, J. W. GIDLEY, WILLIAM PALMER, ALEX. WETMORE, E. A. GOLDMAN. President HAY was nominated as vice-president of the Washington Academy of Sciences.

Ex-president B. W. EVERMANN then gave an illustrated lecture regarding the present condition of the museum of the California Academy of Science and its aims and aspirations. This was discussed by Messrs. E. W. NELSON and VERNON BAILEY.

M. W. LYON, JR., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 500th meeting of the Society was held at the New National Museum, October 17, 1916, at 4.30 p.m. Dr. WALTER HOUGH, of the National Museum, read a paper on *Ancient pit dwellers in New Mexico.*

Dr. Hough said that remains of pit dwellings were indicated on the site of stone ruins explored in western Socorro County, New Mexico, several years ago and that a large cluster of such dwellings not connected with stone ruins was observed subsequently near Luna, in Socorro County. The site was productive of interesting results during an exploration for the Bureau of American Ethnology last summer. The field in which the remains occur had been smoothed over by natural agencies and the positions of the houses were shown only by the stronger growth of vegetation over circular areas, this defining the pits. Some of the pits were cleared, and it was found that they were from 12 to 14 feet in diameter and 5½ feet deep. Remains of roof clay and charred posts and beams indicate that the roof was supported on posts placed around the periphery of the pit. It is thus probable that more than half of the house was underground, and perhaps the position of the walls above ground were banked. The floor arrangement shows a fireplace near the center, a metate and grinding stones near the fire. In one of the pits a burnt clay wall fireplace was found. Adjoining the pits was a rectangular house also rooted with clay. Here were found numerous grinding stones, baking slabs, and remains of pottery, these being about a foot under the surface loam. This house was an open air cooking and mealing shed. Near the first pit excavated was a cemetery of infants; no remains of adults have yet been found on the site.

A dance amphitheater which was about 100 feet in diameter and 10 feet deep lies on the east side of the site. It has been filled by natural agencies with about 5 feet of fire-blackened débris and in it large pine trees have matured. It is on the bank of the former and larger channel of a living stream which traverses the eastern edge of the site. The specimens found are crude metates, rubbing stones, hammer stones, baking slabs, etc.; pottery of Pueblo type, decorated and undecorated and of some crudity; a few bone awls and small obsidian arrowheads. No stone axes were found.

Dr. Hough presented the problem as he found it, and hesitated as yet to pronounce upon the affiliations of the people who constructed the pit houses.

The 501st meeting of the Society was held in the Lecture Hall of the Public Library, on Tuesday evening, November 7, 1916, at 8 o'clock. The speaker was Mr. W. E. SAFFORD, of the Bureau of Plant Industry, U. S. Department of Agriculture. His subject was *Magic plants of the ancient Americans.* The paper was illustrated with lantern slides.

Mr. Safford said that the practice of magic was widely spread in both North and South America in pre-Columbian times, and in connection with it certain plants, principally those having narcotic properties, were used ceremonially, often as incense, or to produce hallucinations, to call up the spirits of the dead, and to expel evil spirits from the sick and insane. The priest of the Temple of the Sun at Sagomozo, in the Andes of South America, prophesied and revealed hidden treasures while in a state of frenzy caused by the seeds of a tree datura (*Brugmansia sanguinea*). This recalls similar practices of the priestesses of the oracle at Delphi. Another Peruvian plant with marvelous properties described by early explorers was *Erythroxylon Coca*, from which the valuable alkaloid cocaine is now obtained. Bags of its leaves accompanied by little gourds containing lime were found by the author in many graves near the Peruvian coast, hanging about the necks of the mummified remains of the dead. On the opposite coast of South America, or rather in Paraguay, grew the highly esteemed *Ilex paraguariensis*, or *yerba mate*. Closely allied to it is the *Ilex vomitoria* of the southeastern United States, from which the Indians made the famous "black drink," used ceremonially as a magic physic, which purged them from evil and which was used also in initiating their youths into manhood. Professional priests, or necromancers, were encountered by Columbus and his companions on the island of Hispaniola, who induced intoxication and called up their *zemi*, or gods, by means of a narcotic snuff, called *cohoba*, inhaled through the nostrils by means of a bifurcated tube. This snuff, hitherto believed to have been tobacco, has been identified recently by the author as the powdered seeds of a Mimosa-like tree, *Piptadenia peregrina*, still used in a similar way by various South American tribes of Indians, by some of whom an infusion of the seeds is also used to induce intoxication, administered as an enema by means of a pear-shaped syringe of caoutchouc. In Mexico, the early missionaries, who were called upon to stamp out the practice of witchcraft, found that the Aztecs paid divine honors to various plants, especially to *huauhtli* (a white-seeded Amaranthus); *ololiuhqui* (a Datura); *peyotl* (a spineless cactus, *Lophophora Williamsii*) also called *teonanacatl*, or "Sacred Mushroom;" and *picietl* (tobacco). Of *huauhtli* seeds, ground to a paste with the syrup of maguey, images were made and adored, and afterwards broken into fragments and served as a kind of communion. This seed was produced in such quantities that it was used in paying tribute to Montezuma, at the time of the Conquest. The *ololiuhqui* was regarded as divine, and it was considered a holy task to sweep the ground where it grew. Its spirit, addressed as the Green Woman (*Xoxouhqui Cihuatl*), was invoked to expel certain diseases and to overcome weaker and inferior spirits in possession of a sick person. It is interesting to note that the use of the *ololiuhqui*, or *toloatzin*, as it was also called (*Datura meteloides*), still prevails among the Zuñi Indians of New Mexico, the Pai-Utes, and several tribes of southern California in certain religious and ceremonial practices, especially in initiating youths into the status

of manhood. The *peyotl*, or *teonanacatl*, called by Bancroft the "flesh of the gods," was used by the Aztecs in nocturnal feasts, very much as it is still used by Indians of the Mexican Sierra Madre and by certain tribes of the United States, who believe the visions induced by it to be supernatural. In ancient times a supply of this little narcotic plant was obtained by runners especially consecrated for the purpose, and its gathering was attended by a most formal ceremony. At the present day it is sent from the locality where it grows, along the Rio Grande, by means of parcel post. Lastly, the ceremonial and religious use of *picietl*, or tobacco, goes back to remote antiquity. No other narcotic plant, perhaps, has become so widely spread or so generally used and beloved by its votaries. Though of subtropical origin its cultivation had extended before the Discovery as far north as the St. Lawrence River. Beautiful pipes of many forms, representing birds, mammals, human heads, etc. have been discovered in Indian mounds near the native city of the speaker, Chillicothe, Ross County, Ohio; and more recently in Scioto county farther to the south.

In addition to the above plants may be mentioned a certain small scarlet bean, the seed of *Sophora secundiflora*, endemic in northern Mexico and southern Texas. This also has narcotic properties, and was so much sought after by certain tribes of Indians that they have been known to exchange a pony for a string of the beans 6 feet in length. In one of the secret societies of the Iowa Indians this bean is used in the initiating ceremonial; the beans are carried as charms or amulets by the members of the society, just as in western Mexico fragments of the *peyotl*, and in southern California parts of the Datura, are carried by their votaries, who believe them to be efficacious against danger and to bring good luck in hunting and war. It is interesting to note a similar practice in the Old World of carrying the root of Mandragora (or a substitute for it) as an amulet; but most interesting of all is the similarity between the beliefs and practices of the inhabitants of the Old World and the New, in connection with narcotic and other plants held to possess magic properties. The lantern slides used to illustrate the lecture were photographs of the various magic plants discussed.

This paper was discussed by Mr. JAMES MOONEY, who for a number of years has given special study to the subject of *peyotl*. Mr. Mooney defended those who are devoted to the peyotl ceremony and claimed that, in most cases, the assertions made against the plant and its users are based upon ignorance of the facts and are without foundation.

The 502nd meeting of the Society was held at the New National Museum on Tuesday afternoon, November 21, 1916, at 4.30 o'clock. Mr. NEIL M. JUDD, of the U. S. National Museum, presented a paper on *New types of Pueblo ruins found in western Utah*, illustrating his paper with chalk drawings.

Mr. Judd described a recent archeological reconnaissance of western Utah conducted under the auspices of the Bureau of American Ethnology, stating that this resulted in the discovery of two types of pre-

historic habitations not previously reported from the Southwest. The first of these was circular in form and was made by leaning logs against cross-pieces supported by four uprights which surrounded a central fire-place. Willows, grass, and clay, in succession, covered the logs. Houses of the second type, occurring usually in groups forming villages, were rectangular in shape and constructed entirely of adobe. A small series of unattached cliff-dwellings, exhibiting certain features common both to structures of this second type and to stone-walled houses south and east of the Rio Colorado, was also described. A careful study of the lesser artifacts recovered from both types of western Utah ruins indicates a close cultural relationship between their respective builders and the inhabitants of prehistoric structures in other sections of the Southwest.

In a discussion of the paper Dr. J. W. Fewkes called attention to the desirability of a more accurate definition of what archeologists mean by a "pueblo." He pointed out that the term is sometimes used loosely to include all kinds of ruined stone buildings in the Southwest. Inasmuch as the pueblo culture area owes its name to characteristic buildings or pueblos, he suggested that the term be limited to terraced, congested community buildings with ceremonial rooms or kivas. If this suggestion were accepted by archeologists, many ruins on the periphery of the so-called Pueblo area would have to be classified as belonging to a prepuebloan phase, or not regarded as pueblos at all.

The 503rd meeting of the Society was held in the Lecture Hall of the Public Library on Tuesday evening, December 5, 1916, at 8 o'clock. At this meeting Prof. W. H. Holmes, of the U. S. National Museum, delivered an address on *Outlines of American aboriginal history*, illustrated with lantern slides.

Introducing his subject, Professor Holmes said it is agreed that the human race is a unit, and that it follows, therefore, that there was but one cradle and that man spread from this over the world. The early chapters of human history must always remain obscure, although evidence has been found carrying the story far back into the remote past. It was the purpose of the speaker to indicate briefly the probable course taken by the human race in spreading from the Asiatic cradle to the New World, and also to indicate the causes and course of cultural development in the various centers of American occupancy and to suggest the causes of decline.

The earliest known traces of man (or man-like being) have been found on the island of Java. In the nature of things, it was a long time before he wandered far from his primeval home. He had to acquire the arts of the hunter and fisher before he could reach the far north and it was doubtless by way of Bering Strait that he reached the New World. Portraits were shown of the various peoples whose ancestors may have been concerned in these ancient migrations—natives of Tibet, China, and Siberia, the Eskimo, the Sioux, the Zuñi, and other typical American Indians; and attention was directed to the

practical identity of these types. Referring to the development of culture in America it was shown that no culture above the hunter-fisher stage ever passed through the Bering gateway. All culture of higher grade is, therefore, American. As the early immigrants reached the more favorable localities of the continent, they engaged in agriculture and became sedentary. This condition led to the development of the simple arts, industries, and institutions belonging to this phase of progress. It was asked, How then do we account for the vast works in the way of temples, pyramids, and tombs, and the vast body of products of the sculptor's art, of highly embellished pottery, textiles, and metallurgy? It was shown that all were due to the dynamic forces of religion manifested through the all-powerful shamanistic classes, who sought above all things to honor the gods and to glorify themselves. But, it was asked, Why are the once splendid cities now in ruin? The reasons are readily found: The energies of the people were broken down by the ever increasing load of super-essential activities. The system which permitted over-growth of these highest manifestations of culture had within itself the germs of disaster.

Numerous slides illustrating various wonderful products of sculptural and architectural genius developed under the absolute control of the Mayan shamanistic priesthood were shown.

The paper was discussed by Dr. E. Hewett, of Santa Fe, N. M., Mr. S. G. Morley, of Cambridge, Mass., and Dr. H. J. Spinden, of New York. Dr. Hewett suggested the influence of environment on the cultural development of a race, citing the discovery of metal by the early inhabitants of Europe and its use in making weapons. Mr. Morley spoke of the Maya hieroglyphs, and Dr. Spinden discussed the culture which preceded that of the Maya in Central America, traces of the agricultural period remaining in crude figurines, and that of the religious period in effigies of serpents and of grotesque gods.

The 504th meeting of the Society was held at the New National Museum, December 19, 1916 at 4.30 p.m. Dr. Truman Michelson, of the Bureau of American Ethnology, presented a paper entitled *Notes on the Peoria Indians.*

Dr. Michelson said that the Peoria Indians have practically lost their ethnology, in the strictest sense of the word, although their language and folklore still remain. A study of these shows very clearly that the Peoria Indians have had two associations, the older and more intimate association being with the Ojibwa group of central Algonkins and the more recent with the Sauk, Fox, and Kickapoo. The terms of relationship support this view, as do the historical facts.

The speaker then showed by means of a blackboard chart the system of consanguinity among the Peoria. In this way it was demonstrated that two factors were involved, i.e., the gentile organization and blood consanguinity.

The paper was followed by a general and interesting discussion. Prof. W. H. Holmes mentioned the old quarries in northeastern Okla-

homa, near the present location of the Peoria Indians, and Dr. Aleš Hrdlička noted the importance of definite recording of the geographic distribution of Indian tribes. In reply to a question by Mr. F. W. Hodge the speaker expressed the opinion that archeological research would throw light on the early material culture of the Peoria. Dr. J. R. Swanton noted that the Indians of the Northwest coast have a myth similar to one related by the speaker, in which bones thrown into the water are said to "come to life." In the legend of the coast Indians the bones are those of a salmon, while among the Peoria the bones are those of a beaver. In response Dr. Michelson stated that the form of this legend which mentions the beaver is limited to a small area.

Frances Densmore, *Secretary*.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, January 20: The Philosophical Society, at the Cosmos Club, at 8.30 p.m. Program:

L. J. BRIGGS: Presidential address.—*The living plant as a physical system.*

Wednesday, January 24: The Medical Society, at the Medical Department of the George Washington University, 1325 H Street N. W., at 8 p.m.

Wednesday, January 24: The Geological Society, at the Cosmos Club, at 8 p.m. Program:

D. F. HEWETT: *The nature of bertonite, and the geologic range of related material in the Big Horn Basin, Wyoming.* 20 minutes.

J. C. HOSTETTER: *The linear force of growing crystals.* 20 minutes. Illustrated.

J. W. GIDLEY: *Origin of the mammals.* 20 minutes. Illustrated.

Saturday, January 27: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, January 31: The Medical Society, at the Medical Department of the George Washington University, 1325 H Street N. W., at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh days of each month.

CONTENTS

Original Papers

Page

Mineralogy.—Magnesioludwigite, a new mineral. B. S. Butler and W. T. Schaller 29

Anthropology.—Significance of the terms for brother and sister among primitive peoples. John R. Swanton 31

Abstracts

Physics 36
Geology 36
Paleontology 39
Technology 39

References

Chemistry 40
Mammalogy 40
Technology 42

Proceedings

The Botanical Society 44
The Biological Society 45
The Anthropological Society 47

VOL. VII

FEBRUARY 4, 1917

No. 3

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII FEBRUARY 4, 1917 No. 3

PHYSICS.—*Standard substances for the calibration of viscometers.*[1] Eugene C. Bingham and Richard F. Jackson, Bureau of Standards. (Communicated by C. W. Waidner.)

For the calibration of viscometers there is a need for one or more liquids which can be easily obtained in pure condition, and which have viscosities that are greater than that of water and that are known with a considerable degree of certainty. The substances selected are mixtures of ethyl alcohol and water, and sucrose and water. Previous work upon water and alcohol being adequate, the present experiments were confined to sucrose and water. The sucrose was purified by repeated recrystallisation from water solution, and contained residual impurities of the order of one-thousandth of a per cent. The compositions of the solutions used in the measurements were determined by density measurements and by polariscopic tests.

The viscometer used in the investigation consisted essentially of a U-tube fitted with a capillary limb surmounted by a bulb with constrictions. The bulb served as a measure of the volume of liquid forced through the capillary. A bulb of similar size and shape was sealed on the other limb. The viscometer was connected to a manometer and an apparatus for the application

[1] To appear in detail as Bureau of Standards Scientific Paper No. 298.

of pressure. From the observations the viscosity was calculated by the usual formula:

$$\eta = Cp\tau - C'\frac{\rho}{\tau}$$

in which η is the viscosity, p applied pressure, ρ density of liquid, τ time of flow, C and C' constants abbreviated from the complete viscosity formula. C' was found by direct calculation, C by measuring the time of flow of pure water at 20°C. The viscosity of water at 20°C. was taken as 0.01005.

The viscosity was measured at a variety of applied pressures. To obtain the true effective pressure, the height of liquid in the manometer was corrected for air buoyancy, column of connecting air, and hydrostatic head of the liquid undergoing measurement. In order to be certain that the drainage of the solution was complete, both the time of flow required to empty and that to fill the bulb were measured. Furthermore, the viscosity was found to be independent of applied pressure. To test the calculations and corrections the viscosity of water was measured over a considerable range of pressures. The value was found to be constant.

In order to avoid the arbitrary scales of commercial viscometers and the inconvenient magnitudes of the absolute units, we suggest the use of the "centipoise" as a unit of viscosity. This is the one-hundredth part of the c.g.s. absolute unit. The centipoise is almost exactly the viscosity of water at 20°C. (0.01005) and, hence, is at the same time the specific viscosity of any substance referred to water at very near 20°C.

The existing data for the viscosity of water have been reviewed in order to obtain a value as far as possible in accord with our present knowledge. The mean value expressed as fluidity is given by the formula:

$$\phi = 2.1482\left\{(t - 8.435) + \sqrt{8078.4 + (t - 8.435)^2}\right\} - 120$$

in which ϕ is the fluidity, and t the centigrade temperature.

The fluidities of mixtures of ethyl alcohol and water expressed as functions of the temperature, and of the weight and volume percentage of alcohol, will be given in the detailed paper.

The viscosity of a 39.99 per cent sucrose solution was measured at temperatures varying from 0°C. to 95°C. The observed values correspond to the formula:

$$t = 0.597\ (\phi + 20) - \frac{1438.6}{\phi + 20} + 38.24$$

On repeating these measurements practically the same values were obtained.

Measurements were made with 20.007 per cent and 59.96 per cent sucrose solutions also. The fluidities at the latter concentration correspond to the formula:

$$t = 1.472\ (\phi + 5) - \frac{323.2}{\phi + 5} + 58.62$$

The values found in the present investigation indicate a higher viscosity than those of previous investigators.

CHEMISTRY.—*Some problems of the oxides of iron.*[1] ROBERT B. SOSMAN, Geophysical Laboratory.

Starting with the general principle that the soundest progress in science is made by proceeding from that which is simple and understandable to that which is more complex and less understandable, various investigators have sought to unravel the complexities of natural rocks and minerals by studying first their simplest constituents. Since it appears that under most rock-forming conditions silica (SiO_2), alumina (Al_2O_3), lime (CaO), and magnesia (MgO) always act as units, these oxides may be taken as the pure components in the fundamental experiments.

With the oxides of iron the case is different. The equilibrium between ferrous and ferric iron in a mineral or rock can vary with every change of temperature and with every change in the amount or pressure of available oxygen. In order to under-

[1] Presidential address, Chemical Society of Washington, January 11, 1917. Presented before a joint meeting of the Chemical Society and the Washington Academy of Sciences.

stand ferrous silicate and the minerals in which it occurs, therefore, we must go back one step further, and study the system iron-oxygen.

THE PHASE-RULE DIAGRAM OF THE SYSTEM IRON-OXYGEN

The logical point at which to begin a survey of the pressure-temperature-concentration relations in the two-component system iron-oxygen is with the pure component iron. We have learned a great deal in recent years about the properties of pure metallic iron, although the difficulty of preparing the metal quite free from its usual impurities of carbon, hydrogen, sulphur, phosphorus, manganese, and silicon, has delayed the determination of its elementary constants.

But when we add oxygen, the second component, to the system we come into a little-known region which extends as far as the compound Fe_3O_4. The solubility of oxygen in solid iron is certainly not large, but has not been accurately determined. Austin[2] states that the oxygen found by analysis of iron bars does not exceed 0.29 per cent, and that the most of this seems to be in the form of oxide films in mechanical admixture. Pickard[3] concludes from his analyses that 0.092 per cent of oxygen is soluble in liquid iron as FeO, although a part of this may separate out on the solidification of the metal. It is thus evident that there is no extensive solid solution of oxygen in iron. But the small quantity that is present has a very large influence, especially on the magnetic properties of the metal, as appears from the work of Yensen.[4]

The next question is, what is the lowest oxide in equilibrium with metallic iron? Ferrous oxide, FeO, has been generally assumed to be the oxide lowest in oxygen, but the data concerning it are far from satisfactory. Various methods for preparing FeO are found in chemical literature. Mr. Hostetter and I have tried several of these, and our experience has invariably

[2] Engineering, **100**: 455. 1915.
[3] Iron Age, **98**: 184–186. 1916.
[4] YENSEN, T. D. Univ. Illinois, Eng. Exp. Station, Bulls. 72, 77, 83. 1914–1916.

been that the product was a mixture of iron (or iron carbide) with magnetite or with some oxide intermediate in composition between FeO and Fe_3O_4. The best work on FeO has been that done by Hilpert, and his conclusion, likewise, is that the various methods commonly cited do not yield FeO, although the product sometimes has an average composition nearly equivalent to the composition FeO.

Hilpert and Beyer[5] found that by reduction of Fe_2O_3 by hydrogen saturated with water vapor they could obtain products which were richer in ferrous iron than Fe_3O_4, but which contained no metallic iron. The higher the temperature of reduction, the higher the percentage of "FeO." A product containing only 1.5 per cent of Fe_2O_3 was obtained by reduction at 1100°; at 700° the upper limit was 85 per cent of FeO. The reaction velocity is so slow, as equilibrium is approached, that it is difficult to say what the final solid phases would be. Hilpert believes that solid solutions exist between Fe_3O_4 and FeO, perhaps with limited miscibility, or even with intermediate compounds.

We can find a possible explanation of the case of FeO by reference to the somewhat analogous oxides of two other metals of the eighth group, namely, platinum and iridium.[6] The evidence indicates that the oxide IrO, within a certain range of temperature, has a higher dissociation pressure than the oxide IrO_2; hence IrO will spontaneously change into a mixture of IrO_2 and metallic iridium, according to the reaction:

$$2IrO = IrO_2 + Ir$$

Thus, if FeO happens, over some particular range of temperature, to have a higher dissociation pressure than Fe_3O_4, it is possible for the following reaction to occur:

$$4FeO = Fe_3O_4 + Fe$$

The existence of such a relation would explain many of the experimental results already obtained, such as the fact that, in

[5] HILPERT, S., and BEYER, J. Ber. deu. chem. Ges., **44**: 1608–1619. 1911.

[6] WÖHLER and WITZMANN. Zs. Elektrochem., **14**: 97–107. 1908. WÖHLER and FREY. Ibid., **15**: 129–142. 1909. A solid solution of IrO_2 with IrO or Ir forms, rather than the pure oxide IrO_2.

our experience, powdered iron heated in oxygen at low pressures always yields a mixture of a black magnetic oxide (perhaps a solution of FeO in Fe_3O_4) and metallic iron. The facts are so few, however, that this explanation is not to be considered as more than a suggestion.

There is one interesting geological application of this relation, if it should be found to exist. Many basic rocks, such as diabase and gabbro, contain metallic iron. The best known occurrence is probably that in Greenland, but other examples exist in all parts of the world. If our supposed oxygen-pressure relationship still holds when the oxides are dissolved in a silicate magma, the following reaction would occur:

$$4FeSiO_3 \text{ (in complex silicate)} \rightleftarrows Fe_3O_4 + Fe + SiO_2 \text{ (in complex silicate)}$$

At constant temperature, increasing pressure would drive this reaction in the direction of diminishing volume. The formation of FeO from Fe and Fe_3O_4 is accompanied by a contraction of volume, according to Hilpert's data, and it appears not unlikely, therefore, that release of pressure in a rising column of molten diabase might alone account for the occurrence of metallic iron in the resulting rock, without the need of recourse to reducing agents such as entrapped organic deposits or dissolved reducing gases. This problem calls for the measurement of dissociation pressures and specific volumes of the oxides and silicates concerned, in the region 900°–1300°.

The same reaction might conceivably be made a basis for a commercial method of making pure iron, free from the usual impurities which come from the use of coke as a reducing agent.

Continuing our survey in the direction of increasing content of oxygen, we come to the compound ferrosoferric oxide, magnetite (Fe_3O_4). Its melting point is 1580°, and it melts sharply to a mobile liquid which crystallizes in octahedra on cooling. Its dissociation pressure is extremely low, being less than 0.04 mm. of mercury at 1200°, and less than 0.005 mm. at 1100°.

Further addition of oxygen brings us into the region between Fe_3O_4 and Fe_2O_3, a region which we have recently investigated

at 1100° and 1200°. These two oxides seem to form a continuous series of solid solutions from Fe_2O_3 to Fe_3O_4, or at least to a point so near Fe_3O_4 that it has not been possible to detect a break in the dissociation pressure curves.[7]

The melting temperatures (solidus and liquidus curves) of the series Fe_2O_3–Fe_3O_4 have not yet been determined. The dissociation pressure rises so rapidly with increase of temperature that at the melting temperature of the solid solution the pressure of oxygen will probably be found to be of the order of several atmospheres for compositions which depart much from Fe_3O_4.

The melting point of Fe_2O_3 can be determined only under sufficient oxygen pressure to prevent its dissociation, and it is impossible to predict whether the melting point will be higher or lower than that of magnetite. The form of the liquidus and solidus curves (continuous, minimum, or maximum) can also not be predicted. The form of these curves is of particular interest in connection with the effect of changing oxygen pressure. At a given temperature it is possible that increasing the oxygen pressure might cause either fusion or solidification of the oxide, or even fusion followed by solidification, depending upon the form of the curves.

The type of solid solution represented by these two oxides of iron deserves a moment's consideration. The special feature of this case is that the two constituents of the solution differ only in the proportion of volatile component which is combined with the non-volatile component. In other words one of the constituent oxides of the solid solution is produced by direct dissociation of oxygen from the other oxide. The case of Fe_2O_3–Fe_3O_4 is thus exactly analogous to the case of $CoCl_2.6NH_3$–$CoCl_2.2NH_3$, in that we may consider Fe as replaced by $CoCl_2$ and O by NH_3. The system just referred to has been studied by Biltz and Fetkenheuer,[8] who find a continuous series of solid solutions, throughout which the NH_3 pressure falls continuously, following a reversed curve of the same form as that shown by the iron oxides.

[7] SOSMAN and HOSTETTER. Jour. Am. Chem. Soc., **38**: 807–833. 1916.
[8] BILTZ and FETKENHEUER. Zs. anorg. Chem., **89**: 106. 1914.

Several interesting problems are raised by the consideration of this type of solid solution. In the first place how are we to picture to ourselves its internal structure? The X-ray analysis of crystal structure is so radically altering our conceptions of the make-up of solid substances that our ideas of solid solutions have not yet become adjusted to the new facts. When it was discovered that certain properties of a solute in dilute aqueous solution made the solute seem quite analogous to a gas, and when it was discovered that solid solutions existed which seemed quite analogous to liquid solutions, we felt secure for a time in this extension of molecular theory from gases over into liquids and solids. The facts now need re-interpreting, but the greatest need is for more facts on the crystalline structure of solid solutions.

Another problem raised by a consideration of the hematite-magnetite series is that of the continuous transition from one crystal class into another. According to the original conception of isomorphism, two compounds could enter into solid solution only if they crystallized in the same system. Now hematite is hexagonal while magnetite is isometric; is a continuous series from one of these systems to the other possible? To say that there is a hexagonal form of magnetite, which is the form that dissolves in hematite, is merely to dodge the issue; such a statement becomes a meaningless form of words if the experimental consequences remain the same whether the supposed second form exists or not.

A consideration of the point systems from which the crystal classes can be made up shows that we can in reality get a continuous transition from cubic to hexagonal. Suppose a cubical portion of some cubic lattice to be standing on one of its corners; then if it be compressed along the vertical diagonal axis it changes into a rhombohedron which becomes flatter with increasing compression, and the rhombohedron is a hexagonal form. This transition requires of course that the lattice of the isometric and hexagonal forms be thus transformable, and this can be determined for hematite and magnetite only by X-ray studies of their crystals. If it should then be proved that the struc-

tures of the ordinary forms of hematite and magnetite are not thus transformable, then by geometry alone, without the aid of chemistry, could we predict that there must be a break in the solid-solution series between these two oxides?

A third problem of the hematite-magnetite series concerns the escaping tendency or fugacity of the oxygen which dissociates from the oxide. What determines the equilibrium pressure of this oxygen for a given composition of the solid solution? It is interesting to note the peculiar form of the oxygen pressure curve in this series. The middle portion is fairly flat, and the pressure changes slowly with change of composition. As the composition of magnetite is approached, however, the pressure begins to fall rapidly, and, conversely, it rises rapidly as the composition Fe_2O_3 is approached. We have been able to show[9] that the dissociation pressure of the first small portion of oxygen from pure Fe_2O_3 at 1200° is of the order of magnitude of an atmosphere of oxygen, although the pressure rapidly falls to a few millimeters as dissociation progresses.

From a theoretical standpoint there are two ways of looking upon this form of dissociation curve. On the one hand, we may consider that the curve is asymptotic to the axis of ordinates; in other words, the initial composition of the crystal corresponds exactly to the formula Fe_2O_3, and the dissociation pressure of the first few atoms of oxygen is very high. These atoms come from all parts of the crystal, and their removal brings into play forces which greatly restrain the fugacity of all the remaining oxygen atoms, causing a rapid fall in the dissociation pressure.

On the other hand, we may consider, as Langmuir[10] and others have shown, that there are free chemical forces at the surface of the crystal, and that these forces hold atoms of oxygen "adsorbed" on the surface when the crystal is exposed to air. The initial composition then is Fe_2O_{3+x}, in which x is a very small number. The fugacity of these surface atoms is high, but not much higher than that of oxygen atoms just within the surface. Oxygen will begin dissociating from interior parts of the crystal,

[9] HOSTETTER and SOSMAN. Jour. Am. Chem. Soc., **38**: 1188–1198. 1916.
[10] LANGMUIR, I. Jour. Am. Chem. Soc., **38**: 2221–2295. 1916.

therefore, before all the adsorbed oxygen is removed from the surface. Mathematically speaking, we may say that the dissociation pressure curve is not asymptotic to the axis of ordinates, drawn at the composition Fe_2O_3, but crosses this axis at a small angle. This second conception of the case gives, I believe, the better interpretation of the facts.

MAGNETIC PROPERTIES AND POLYMORPHISM OF THE OXIDES

The problems so far considered are all problems which are common to nearly all the chemical elements and their compounds. But there is one field of physics in which iron holds at present the first place in interest, namely, the field of magnetism. Progress in the experimental study of magnetic properties has lagged behind experimental progress in electricity, chiefly because we possess no magnetic insulator. As has been well stated by Mr. Sanford at a recent meeting of the Philosophical Society of Washington, "Measuring magnetic properties is like measuring electrical resistance with the Wheatstone bridge and all the connections immersed in a conducting liquid." Nevertheless, rapid progress is now being made on several lines of magnetic research.

The oxides of iron have been, from this standpoint, rather neglected. Measurements will be found here and there in connection with studies of the salts of iron, crystalline or dissolved. From these it is clear that the oxides are not to be classed magnetically with the majority of the iron compounds. Ferric oxide is abnormally low in susceptibility, in comparison with the common salts of iron. Ferrosoferric oxide, on the other hand, belongs, as is well known, among the highly ferromagnetic substances. Ferrous oxide, again, seems to be in a class with ferric oxide. Intermediate oxides possessing a variety of combinations of magnetic properties also exist.

The inversions in ferric oxide first attract our attention. Honda[11] has found that at liquid air temperatures ferric oxide has only about two-thirds as great a susceptibility as at room temperature, and that a change occurs rather suddenly in the

[11] Honda, K., and Soné, T. Sci. Rep. Tohoku (Sendai), 3: 223–234. 1914.

neighborhood of −40°. The susceptibility rises to a maximum at about 600°, and then falls rapidly to about half value at 690°, where the curve changes direction practically by a right angle, the susceptibility being nearly constant from 690° to 1300°.

We have confirmed the high temperature inversion, placing it at 678° by means of thermal curves.[12] The inversion is sharp and reproducible, and appears on both rising and falling temperature curves. The −40° inversion we have not yet investigated thermally.

Curie[13] discovered a similar magnetic inversion in magnetite at about 535°. Barton and Williams[14] confirmed this inversion, placing it about 545°. Weiss and Foex[15] placed the inversion at 581°, Wologdine[16] at 525°. The temperature of the magnetic inversion is undoubtedly influenced by the magnitude of the induction or of the magnetizing force. No thermal study of the inversion has yet been made. The principal precaution to be observed is the avoidance of oxidation of the magnetite by air. Some of the conclusions of Weiss and Foex seem to have been vitiated by a slight oxidation of their artificial magnetite, and a faint trace of the 678° point of Fe_2O_3 appears on their magnetite curve.

The magnetic inversion in pure iron occurs at about 770°, varying somewhat with the magnetizing force to which the iron is subjected. It is found thermally at 768°, and by electrical resistance, at 757°. This is the thermal inversion known as A2, whose existence in pure iron free from carbon was seriously questioned some years ago, but which has been established as an independent and characteristic inversion by the excellent work of Burgess and his co-workers at the Bureau of Standards.[17]

These magnetic inversions, which occur not only in iron, magnetite, and hematite, but also in various ferrites, are all very

[12] Sosman and Hostetter. Jour. Am. Chem. Soc., **38**: 831. 1916.
[13] Curie, P. Ann. chim. phys., **5**: 322. 1895.
[14] Barton, E. H., and Williams, W. British Assoc. Rep., pp. 657–658. 1892.
[15] Weiss, P., and Foex, G. Arch. sci. phys. (Genève), **31**: 5–19, 89–117. 1911.
[16] Compt. rend., **148**: 776. 1909.
[17] Burgess and Crowe. Bull. Bur. Std., **10**: 315–370. 1914. Burgess and Kellberg. Ibid., **11**: 457–470. 1914.

similar in the form of their temperature-magnetism curves. In each case the effect of rising temperature appears some distance below the inversion point, and increases more and more rapidly as the inversion is approached. One cannot avoid the conclusion that these inversions all have the same fundamental basis. When that basis is found, we will have considerably advanced our knowledge both of polymorphism and of magnetism.

So much has been said about polymorphism (including under this term allotropy, polymerism, and all the other names given to the phenomena of sudden change of physical and chemical properties without change of percentage composition), and so much that has been said is mere quibbling over the meanings of words and phrases, that I shall not undertake any general review of the questions that are raised by the inversions of iron and its oxides. But there is one problem to which considerable attention has lately been given, namely, the problem of the two types of polymorphism in crystalline substances.

Polymorphic changes in crystalline solids can be divided roughly, as is well known, into two groups. On the one hand, there are those changes which carry with them rather profound changes in physical and chemical properties and which often require considerable time to bring about. On the other hand are those reversible changes which occur without delay at a given temperature and which involve relatively small changes in crystal form and in physical properties. An excellent example of a substance showing both types distinctly is silica. SiO_2 occurs in three principal forms, quartz, tridymite, and cristobalite, which are only slowly transformed one into another, and which have certain ranges of stability outside of which they frequently occur in an unstable but very persistent state. Each of these principal forms, on the other hand, possesses one or two inversion points, at which reversible crystalline changes occur: quartz at 575°; tridymite at 117° and 163°; cristobalite at a temperature varying from 200° to 275°, depending upon the previous history of the crystal.[18]

[18] FENNER, C. N. Am. Jour. Sci., **36**: 331–384. 1913.

Two different views have been held concerning the relation of these two classes of polymorphic inversion, although in our present ignorance of atomic structure neither can be very precisely stated. It has been supposed, on the one hand, that the slow changes were the fundamental ones, involving a rearrangement of the atoms in the molecule or a change in the molecular weight, the expression "molecular weight" being considered to have a meaning in the solid as in the gaseous state. The rapid reversible inversions, then, were held to be merely rearrangements among the molecules, involving slight changes in the crystalline form or symmetry.

But on the other hand we may consider the rapid reversible inversions as the fundamental ones, possibly occurring even within the atomic nucleus itself, and thereby necessarily producing some corresponding change in the spacing of the atoms. The slow and sometimes irreversible changes would then be the less fundamental, involving only a re-grouping of atoms or atom complexes.

The second of these two views seems to me to be supported by the phenomena of polymorphism of the oxides of iron. It is obvious that the change can not be one that occurs in the iron atom independently of its chemical environment, for the magnetic inversion occurs at different temperatures in the different oxides and carbides. Furthermore, corresponding inversions are yet to be found in various other compounds of iron. But there is one oxide of iron which I have not yet touched upon, whose properties shed considerable additional light on the problem. I refer to the magnetic ferric oxide which was discovered by Robbins[19] in 1859, was almost forgotten until recently studied by Hilpert,[20] and on which we are now engaged in further experiments.

[19] ROBBINS, J. Chem. News, **1**: 11–12. 1859. Its discovery has usually been ascribed to MALAGUTI, F. Compt. rend., **55**: 350–352. 1862.

[20] HILPERT, S. Ber. deu. phys. Ges., **11**: 293–299. 1909. Hilpert's rather disappointing conclusion from his excellent experiments is that "Fe_2O_3 functioning as an acid is the carrier of magnetism." But what is "Fe_2O_3 functioning as an acid" in a compound whose total composition is expressed by the formula Fe_2O_3? Furthermore, as Hilpert himself recognizes, not all "ferrites," in which Fe_2O_3 is assumed to be the acidic oxide, are ferromagnetic.

If precipitated magnetite is oxidized by ammonium persulfate, or even by atmospheric air at a low temperature, the product, although it contains almost no ferrous iron and is reddish brown in color, is practically as magnetic as magnetite itself. If this magnetic oxide is heated to 750° for a few minutes, its highly magnetic character is lost, and it becomes like ordinary ferric oxide. What is still more remarkable is that the magnetic Fe_2O_3 has a Curie inversion just above 500°, similar to that of magnetite.

Here, then, we have as fundamental a chemical change as it is possible to get—no mere polymerism, but a change in the formula weight with a reduction of the ferrous iron content from 33⅓ per cent to zero; yet the magnetic susceptibility and inversion point remain the same. Except for the color, it is as if we had merely ground up the magnetite and mixed it with powdered solid oxygen.

A consideration of the preceding facts concerning the inversions of iron and its compounds, and especially of the interesting properties of the magnetic form of Fe_2O_3, suggest that the magnetic properties and the inversions of iron and its compounds are bound up with the *spacing and arrangement of the iron atoms*, almost without regard to the other atoms present.[21]

What is this structure of the iron atoms which produces the high permeability, and what is the nature of the intra-atomic change at the inversion point?

These problems are on the way to a solution, for Hull has recently found by means of X-ray spectra that the lattice of metallic iron is the centered cube.[22] He discovered also that this structure seems to remain unchanged through both the

[21] This has been suggested for the Heusler alloys: TAKE. Faraday Soc. Trans., 8: 177. 1912. Professor PUPIN, speaking in the recent symposium on the structure of matter, at the American Association meeting in New York, December 27, 1916, stated that he had come to the conclusion from the magnetic properties of very pure iron that its magnetism is intimately related to its crystalline structure. On the other hand, as Hilpert points out, precipitated oxides that are apparently amorphous and that pass readily into colloidal solution can be made, which are magnetic and possess magnetic inversions. Have the particles of these colloids a microcrystalline structure, as yet unrecognized?

[22] Paper presented at the Cleveland meeting of the American Physical Society, November, 1916.

A2 and the A3 inversions, further confirming the view expressed above, that these inversions are intra-atomic. Further light could be obtained on the problem by a comparison of the structures of the magnetic and the non-magnetic forms of Fe_2O_3.

This apparent dependence of magnetic properties upon the arrangement of the iron atoms in space opens up interesting possibilities. If magnetite can be oxidized to ferric oxide without loss of its magnetism, it may be possible to convert it into other compounds, or even to convert metallic iron into compounds of iron, in which the arrangement of iron atoms will remain undisturbed. A highly magnetic compound of iron with a high electrical resistance, for example, might possess industrial as well as academic interest.

Having barely touched upon some of the problems in chemistry and physics that are raised or partially solved by the study of the oxides of iron, I wish to devote the little time that remains at my disposal to the consideration of a few of the geological problems connected with these oxides.

THE OXIDES OF IRON AS RELATED TO CERTAIN GEOLOGICAL PROBLEMS

The oxides of iron rank high among the earth's important minerals, since metallic iron is manufactured almost exclusively from oxide ores.[23] Questions of genesis of the ores of iron therefore furnish topics of perennial interest to the economic geologist. The widespread occurrence of these ores makes them also of interest to the student of historical and structural geology.

At the present time the so-called magmatic and pneumatolytic ores are attracting the most attention from a scientific standpoint, though economically they are secondary in importance to the sedimentary and residual ores. The magmatic-pneumatolytic ores range in composition all the way from magnetite to hematite. Two different modes of origin account for them. Certain large magnetite deposits are claimed to have been deposited in the lower portion of large igneous masses by gravitative settling of magnetite crystals while the mass was still molten. This

[23] Carbonate ore formed only 0.006 per cent of the production in the United States in 1915. (E. F. Burchard.)

is the explanation offered for many of the deposits of titaniferous magnetite, such as the Ramsoy deposits of Norway.[24] It has also been suggested that the magnetite may have separated by gravity as a liquid or partly liquid layer while the entire magma was still molten.[25] These explanations based on magmatic differentiation have met with various difficulties, geological as well as chemical and physical. The separation of a liquid layer of pure magnetite, for instance, is hardly believable, since the melting point of magnetite is 1580°, whereas the intruding rock bodies from which it separated could hardly have been at a temperature of more than 1000°. Whether small quantities of other substances might greatly lower the melting temperature of magnetite is one of the problems yet to be solved experimentally.

The other mode of origin assumes that the iron was carried in the hot solution or vapor given off by an intruding igneous mass. There are many deposits for which this mode of origin seems well established. Examples of these are the magnetite deposits of Cornwall, Pennsylvania,[26] and the hematite-magnetite ores of the Island of Elba.[27]

An interesting feature of the latter, which we discovered in the course of some magnetic measurements, is the zonal development of certain crystals.[28] The hematite crystals from Elba are well known for their large size and excellent development. They are not pure Fe_2O_3, however, but contain a considerable percentage of ferrous iron. By chemical analysis and by magnetic measurements we have shown that the ferrous iron is zonally distributed, being higher in the core and base of the crystal and lower in its outer surface and free-growing tip. Evidently, the temperature or oxygen concentration, or both, were changing continuously in one direction while these crystals were being deposited.

The reactions that will lead to the deposition of hematite, hematite-magnetite, or pure magnetite from a vapor or a liquid

[24] FOSLIE, S. Norges Geol. Unders., vol. 4, 1914.

[25] DALY, R. A. *Origin of the iron ores at Kiruna.* Vetensk. prakt. Unders. Lappland. Geology, No. 5. 1915.

[26] SPENCER, A. C. U. S. Geol. Survey, Bull. 359. 1908.

[27] LOTTI, B. Mem. descr. carta geol. Italia, II. 1886.

[28] Jour. Wash. Acad. Sci., **6**: 309. 1916.

solution are yet to be investigated. It is not certain, even, what compounds of iron were originally present. The natural suspicion is that the iron was present as chlorides or fluorides, since these compounds are known to be volatile at comparatively low temperatures. Many geologists have objected that in some cases the associated rocks show no trace of alteration by pneumatolytic action, or contain little or none of the element supposed to have been combined with the iron. The Kiruna magnetite ore-body of Sweden, for instance, shows sharp contacts against unaltered normal prophyries. But in the face of a phenomenon such as that seen at Kilauea, where vast quantities of sulfur and its compounds are given off from the lava lake, leaving hardly a trace of sulfide of any kind in the solidified lava around the crater, we need not feel discouraged about proceeding with experiments on the deposition of iron oxides from those compounds which are readily volatile and on which the basic data of temperature and concentration, at least, are obtainable.

One set of facts regarding hematite deposits of the magmatic-pneumatolytic type is to be noted at this point, namely, their magnetic properties and their content of ferrous iron. We have found by some preliminary, as yet unpublished, measurements that the force exerted upon a solid solution of Fe_3O_4 in Fe_2O_3 by a non-uniform magnetic field is roughly proportional to the percentage of FeO. This holds true for both artificial and natural oxides, including even some martites high in ferrous iron. On the other hand, oxides containing ferrous iron (perhaps as carbonate or as other compounds), but in which the FeO is not in solid solution, such as the limonite from Mt. Ktaadn, Maine, have a much lower susceptibility than the corresponding solid solution.

Again, an oxide formed by the oxidation of precipitated magnetite, as has been mentioned above, may have a very high susceptibility, although the percentage of FeO may be very small. We have examined one such oxide found by Messrs. Graton and Butler in a gossan deposit. Hilpert reports that examples have been found in Europe in association with carbonate ores which

are undergoing oxidation. The usual "magnetic hematite," however, owes its magnetic properties to its ferrous iron content.

A simple magnetic test, then, combined with a determination of the ferrous iron, permits certain preliminary conclusions as to the origin of many natural oxides of iron. But there are other magnetic properties which we have not yet touched upon, which may be expected to vary with the composition and constitution of the oxide, such as the remanence and the coercive force, and especially the variation of the magnetic properties with temperature. This correlation of magnetic, physical, and chemical properties is not a small task, but it is one for which the apparatus and methods are now in good working order.

The remanence, or permanent magnetization, offers particular interest. It is well known that magnetite crystals are frequently found which are very strong permanent magnets; in fact the history of magnetism dates from the discovery of these "lodestones" by the ancients. Yet most natural magnetite is not polarized. What causes have produced the polarization and how are they related to the origin and history of the ore?

There is time to touch only in the briefest way on the problems connected with other types of iron ores. The study of replacement ores leads us into the still obscure problem of replacement as a geological phenomenon, ably discussed by Lindgren in a recent paper[29] but still, unfortunately, the subject of more discussion than experiment. The secondary concentration of oxide ores by circulating waters is another problem in chemistry at ordinary temperatures which has not yet received the attention it deserves.

Even the origin of ores which are admittedly almost unaltered is still somewhat obscure. The genesis of residual ores such as those of Cuba is not so much a problem of the oxides of iron, since these play rather a passive role, as of the weathering of iron-bearing silicates. But the origin of certain sedimentary deposits is a specific problem in the chemistry of iron, complicated, however, by a new factor, the biological. It has long been known that some of the higher bacteria play a part in the pre-

[29] LINDGREN, W. *The nature of replacement.* Econ. Geol., **7**: 521–535. 1912.

cipitation of hydrated ferric oxide, and the number of forms which are known to be associated in some way with the precipitation is constantly increasing. It is not yet clear in all cases whether the organism actually brings about the reaction through its own life processes, whether the precipitation is due to the decomposition of the dead organism, or whether the organism acts merely as a nucleus for the collection of agglomerating colloidal oxide. The origin of the immense and very pure iron ores of Minas Geraes, Brazil, is ascribed by Harder and Chamberlin[30] to bacterial activity, apparently for the indirect reason that there are objections to any other mode of formation. The reader is left with the uneasy feeling that perhaps only our lack of knowledge prevents our objecting to the bacterial explanation as well.

There is one possibility which deserves attention in this connection. Experiments with closed tubes show that a comparatively moderate increase of temperature will hydrolyze various ferric salt solutions, and precipitate ferric oxide, which does not redissolve. These ferric solutions seem relatively unstable and easily hydrolyzed, and the colloidal ferric oxide only needs to be agglomerated to form a precipitate that will settle. Are there any possible variations in the composition, concentration, or temperature of sea water which would cause it to precipitate the ferric oxide from a hydrolyzed, even very dilute, ferric solution in much the same way as the Mississippi silt is precipitated by the waters of the Gulf of Mexico? Bacteria, able and willing to take advantage of the conditions favorable to the reaction, need not be excluded, but, as may be the case with calcium carbonate,[31] inorganic causes may be primarily responsible.

The intimate association of silica with many ores, amounting even to chemical combination, as in some of the siliceous ores of the Lake Superior region, may represent a simultaneous agglomeration of colloidal silica and ferric oxide, or an adsorption of ferrous and ferric iron by agglomerated silica. It is to be noted, also, that such precipitated colloids can sometimes be

[30] Jour. Geol., **23**: 385–404. 1915.

[31] See Johnston and Williamson. Jour. Geol., **24**: 729–750. 1916.

re-dispersed (peptonized) by pure water, simply through the leaching out of the salts carried down by them from the strong precipitating solution. A method of secondary concentration is thereby suggested. It is evident that from studies in colloid chemistry we may expect considerable advances in our knowledge of the sedimentary ores.

I have presented a rather varied list of problems, some of which may seem remote from pure chemistry, but I may possibly find an excuse in the fact that this meeting has been held as a joint meeting of the Chemical Society and the Washington Academy of Sciences. As soon as we begin to consider them in detail, we find that the problems of the oxides of iron are but phases of some of the greater problems of chemistry, physics, biology, and geology. And they can not be solved by taking thought about them; new facts, to be yielded by new experiments and new observations, are demanded. Nor are the problems as simple as some of them may have appeared from my statement of them. The chemist is amazed by the facile transformations of iron from ferrous to ferric, beholding the two states of oxidation acting like two absolutely different elements. The physicist stands appalled before the spectrum of iron, realizing the many unknown quantities hidden behind its thousands upon thousands of lines. Even the layman can get a vivid realization of the complexity of the problems involved; he has but to walk out through the country round about Washington and note the bewildering play of inorganic colors everywhere about him, ranging from deep brown-black through various shades of drab, brown, purple, and maroon, and through the many tints of pink, ocher, and rose, to the most brilliant of reds and orange-yellows, and then realize that almost every one of these hundreds of colors is due to an oxide or hydrated oxide of iron; he will begin to realize then that our chemical knowledge of these oxides is almost infinitesimal. One thing only is clear to us, and that is that we are only skirting around the edges of that vast body of knowledge about iron and its oxides which is, as the mining geologist says, "in sight," not to mention the unsuspected problems that lie "in depth," far beyond our farthest plans for research.

GEOLOGY.—*Note on the diffusion of sodium chloride in Appalachian oil-field waters.*[1] G. B. RICHARDSON, Geological Survey.

During the summer of 1915, while working in the oil fields of Butler County, Pennsylvania, I became interested in the common occurrence of brines in oil wells. Samples of salt water were collected and an analysis (A) of one was made in the Geological Survey laboratory. This analysis is compared with another analysis (B) of deep-seated water from Washington County, Pennsylvania, made by Steiger (see table 1). The wells from

TABLE 1

ANALYSES OF WATER FROM DEEP WELLS IN WESTERN PENNSYLVANIA

	COMPOSITION OF DISSOLVED SALTS	
	A	B
Cl	62.29	61.38
SO_4	0.10	0.02
HCO_3	None	....
CO_3	None	None
Br, I	....	0.26
Na	27.59	24.50
K	0.10	1.97
Li	Trace	....
Ca	8.40	9.56
Mg	1.47	0.94
Sr	Trace	1.31
Ba	Trace	Trace
Fe''	0.05	0.06
Fe'''	Trace	....
	100.00	100.00
Concentration, parts per million	131,890	263,640

A. Water from "hundred-foot sand" at depth of 1359 feet, in well on farm of Charles Hoffman, 5 miles northeast of Butler, Pennsylvania. Analysis by W. B. Hicks and R. K. Bailey, U. S. Geological Survey.

B. Water from Oriskany sandstone at depth of "6300" (6260?) feet, in well of Peoples Natural Gas Company, 5 miles northwest of McDonald, Pennsylvania. Analysis by George Steiger, U. S. Geological Survey. See U. S. Geol. Survey Water-Supply Paper 364, p. 9, 1914.

[1] Published by permission of the Director, U. S. Geological Survey.

which the samples were taken are about 40 miles apart, and the water-bearing horizons, of Devonian age, are separated stratigraphically about 4500 feet.

The history of deep-seated waters of this kind is a subject of debate. In a recent number of *Economic Geology* I have suggested, as a working hypothesis, that the Appalachian oil-field brines are a mixture of waters originally occluded with the sediments when deposited and of meteoric waters of later origin which have entered the rocks during periods when the region was above sea level; that these waters have leached great masses of sedimentary beds containing disseminated salt, and that they have undergone a series of changes in composition, the saline matter tending to accumulate because of the slow circulation dependent on the synclinal structure of the region. Among other causes of the sodium chloride content of the waters and of the increase of concentration with depth, I suggest that diffusion from beds of rock salt may be an important factor. Such beds in the Salina formation are known to underlie at least part of the Appalachian oil-fields. Thick deposits of rock salt actually occur 600 feet below the horizon in the well from which the water of sample B was obtained, and others may occur.

It is worthy of consideration that beds of shale, especially connecting lenses of sandy shale, separating the more porous beds of sandstone in the Appalachian oil-field section may be porous to such an extent that there exists a continuous, though very irregular, network of minute pore spaces connecting the beds of rock salt with the overlying beds in which salt water is found. The deep-seated waters are under great artesian pressure, as shown by the fact that in the well from which the sample represented by analysis B was obtained the water was forced 4000 feet above the horizon where it was encountered in drilling. Such pressure tends to fill with water the pores even of very fine-grained strata, and it seems plausible that in the rocks of the Appalachian oil-fields there are continuous pore spaces occupied by water. If such conditions exist, diffusion must act.

Table 2, based on a paper by Becker[2], was kindly prepared for me by C. E. Van Orstrand.

TABLE 2

MIGRATION OF SODIUM CHLORIDE IN PURE WATER

DISTANCE	TIME	CONCENTRATION
meters	*years*	
000	1,000,000	1.00
500	1,000,000	0.06
1000	1,000,000	0.0002
1500	1,000,000	0.00000003
000	10,000,000	1.00
500	10,000,000	0.56
1000	10,000,000	0.24
1500	10,000,000	0.08
000	20,000,000	1.00
500	20,000,000	0.68
1000	20,000,000	0.41
1500	20,000,000	0.21

The concentrations are expressed in terms of the initial concentration at the plane of contact between a bed of salt and the base of a column of initially pure water. It is assumed that the initial concentration remains constant.

The computed concentrations are of course only suggestive, and the figures can not be directly applied to the Appalachian region because initially pure water was assumed in computing the table, whereas the water through which diffusion may have occurred must have been initially saline. Nevertheless, the table is of interest in an attempt to account for the high concentration of the brine represented by analysis B and for the general increase in concentration of Appalachian oil-field brines with depth.

[2] BECKER, G. F. *Note on computing diffusion.* Am. Jour. Sci., **3**: 220–226. 1897.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*The Gold Log mine, Talladega County, Alabama.* E. S. Bastin. U. S. Geological Survey Bulletin 640-I. Pp. 159–161. 1916.

The geologic features of a gold mine that has been worked intermittently for seventy years near Talladega, Alabama, are described. The country rock is Talladega slate, probably of Lower Cambrian age. The ore consists of (1) irregularly interlocking white to light-gray quartz, white to pale-pink calcite, and very minor amounts of sulphides and free gold, and (2) schist partly replaced by some or all of these minerals. Chalcopyrite is the principal sulphide. Free gold occurs locally in irregular masses in the quartz.

The value of the gold and silver recovered is reported to average about $4 to the ton of ore treated. R. W. S.

GEOLOGY.—*Ozokerite in central Utah.* Heath M. Robinson. U. S. Geological Survey Bulletin 641-A. Pp. 1–16, with 1 plate. 1916.

The American needs for ozokerite (a substance commonly known as mineral wax) have been largely met in the past by imports from the Galician mines in Austria, but interest in the domestic supply has recently been stimulated. The largest district in the United States in which it has been mined and prospected is an area in central Utah a little more than 12 miles long and from 1 to 4 miles wide between Gilluly and Colton.

The rocks of this field have a total thickness of about 4000 feet and were deposited as nonmarine sediments in early Tertiary (Eocene) time. The lower 1000 feet of the beds exposed are known to contain ozokerite, and the remaining 3000 feet contain bituminous or oil shale

interbedded with other rocks. The principal ozokerite mines and prospects have been opened in the Wasatch formation and are scattered irregularly through a stratigraphic distance of 600 to 700 feet. The ozokerite fills cavities that have resulted from fracturing. The composition, properties, origin, and uses of ozokerite are discussed, and the mines and prospects are described. R. W. S.

GEOLOGY.—*The oil and gas geology of the Foraker quadrangle, Osage County, Oklahoma.* K. C. Heald. U. S. Geological Survey Bulletin 641-B. Pp. i–iv, 17–47, with 2 plates and 11 figures. 1916.

This paper describes and portrays those features of the Foraker quadrangle that may be of interest and assistance in the discovery and development of accumulations of oil and gas. Under the heading "Stratigraphy" those strata valuable as key horizons in mapping structure are described in detail, and the probable positions of oil sands are given. The geologic structure is portrayed by map and stereogram, and the anticlines believed to be favorable for the accumulation of oil and gas are described in detail. In conclusion specific recommendations for prospecting are given, and the writer's belief concerning the probability of the occurrence of oil and gas accumulations is set forth. R. W. S.

GEOLOGY.—*Possibilities of oil and gas in north-central Montana.* Eugene Stebinger. U. S. Geological Survey Bulletin 641-C. Pp. 49–91, with 4 plates. 1916.

The thick bodies of Upper Cretaceous shale with which most of the oil and gas in both Wyoming and Alberta are associated are known to be continuous between these two localities under the plains of Montana, making it apparent that favorable structural features, especially anticlines and domes similar to those that are productive in Wyoming and Alberta, offer a chance of success with the drill in this part of Montana. The facts observed appear to warrant the conclusions that a considerable gas territory, comparable in extent to the Alberta fields, may be found, and that the area shows some probability of yielding oil.

The character and distribution of the sedimentary rocks, particularly those of importance in the search for oil and gas, are discussed, and the geologic structure of north-central Montana is described. Particular attention is paid to the structural features of the area of tilted and faulted rocks north and south of the Bearpaw Mountains. R. W. S.

GEOLOGY.—*Molybdenite and nickel ore in San Diego County, California.* F. C. CALKINS. U. S. Geological Survey Bulletin 640-D. Pp. 73–82. 1916.

Molybdenite has been reported to occur at several places in San Diego County. The deposit near Ramona, which has attracted most attention, was visited in December, 1915. The molybdenite at this locality is unevenly disseminated in an aplite dike which cuts granite, the principal rock of the region. The deposit has not been shown to have commercial value, though further development and prospecting seem to be warranted.

A nickel prospect, the Friday mine, near Julian, was also visited. The nickeliferous deposit, which has been explored to a depth of 200 or 300 feet, lies at an irregular contact between mica schist and gabbro. It consists mainly of pyrrhotite, but contains pyrite, chalcopyrite, and an iron-nickel sulphide, probably polydymite. Both in constitution and mode of occurrence it resembles the Sudbury deposits and is presumably similar in origin. The sulphides are high enough in nickel to constitute ore, provided a fairly large body of them can be uncovered.

F. C. C.

GEOLOGY.—*Gypsum in the southern part of the Bighorn Mountains, Wyoming.* CHARLES T. LUPTON and D. DALE CONDIT. U. S. Geological Survey Bulletin 640-H. Pp. 139–157, with 3 plates. 1916.

Gypsum has been known to occur in a belt of rocks surrounding the Bighorn and Owl Creek mountains, Wyoming, from the early days of exploration. The amount of this material at several places is great, but owing to the slight demand for it little attention has been given to its utilization until the last few years.

The gypsum occurs at two horizons—the upper at or near the top of the Chugwater formation, or Red Beds, and the other in the upper part of the Embar formation. Only the upper bed, however, is of economic importance at Sheep Mountain and in the vicinity of Thermopolis.

The rocks exposed in the region described in this report range in age from pre-Cambrian to Quaternary. The Embar and Chugwater formations, which contain the gypsum beds, are described in detail.

R. W. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 781st meeting was held on January 6, 1917, at the Cosmos Club. Vice-President SOSMAN in the chair; 37 persons present. The minutes of the 779th meeting were read in abstract and approved.

Mr. E. BUCKINGHAM gave a paper on *The effect of elastic strain on the equilibrium temperature of a solid and its liquid.* By methods not involving any reference to the details of the theory of elasticity, a general formula was deduced for the effect on the equilibrium temperature of a solid and a liquid under a stress which produces a strain in the solid at the surface of contact with the liquid. No restrictions were imposed on the nature of the body or on that of the strain, except that the strain must be non-dissipative.

The general formula was applied to the case of linear compression, and the result compared with some other formulas which have been proposed. It agrees with Riecke's formula but does not agree with the interpretation sometimes given to Poynting's formula. Comparison with Bridgman's formula did not lead to any definite conclusion.

Mr. E. D. WILLIAMSON gave a second paper on the same subject. The particular case of an isotropic solid under the influence of a one-sided thrust was treated. Formulas were deduced by methods similar to those used by Gibbs for the change of the equilibrium temperature on the face where the thrust was applied, and also at the free surface, on the hypothesis in each case that a reversible equilibrium is possible. At the free surface the change of temperature is always negative and small, i.e. at such a surface the melting point is always lowered by a small amount by any strain whatever. On the other hand at the surface where the stress is applied the effect is very much greater and is negative for a push but positive for a tension. The possibility of the physical realization of this second case is in doubt.

The method can be extended to the case of solubility by the introduction of another variable—namely, the concentration of the solution. The results are similar to those mentioned above, the solubility being very slightly increased over the free surface but increased or decreased on the stressed surface by a push or a tension, respectively, by a much greater amount.

Mr. J. C. HOSTETTER then gave an illustrated communication on *The influence of non-uniform pressure on solubility.* It is possible that fluctuating temperature and, perhaps, some indirect effects brought

about by pressure may account for the solidification of crystals compressed in contact with their solution by loosely fitting pistons—as found by James Thomson, Le Chatelier, and Spring—without the necessity of postulating large increases in solubility due to pressure.

In preliminary experiments, individual crystals were subjected to stress at constant temperature by direct loading, and the effect on the concentration of the surrounding solution studied, by measuring the conductivity. No change in concentration was found. The test was sufficiently sensitive to show that the effect of non-uniform pressure is much less than that produced by the same pressure acting uniformly, and not many times greater, as had been postulated by Johnston and Adams.

However, in another series of experiments in which an unloaded crystal was placed alongside a loaded crystal, the former grew at the expense of the latter, showing that a very slight increase of solubility was produced by the stress. The method of loading the crystals has a large influence on the effects found, thus indicating the importance of the stress distribution.

In conclusion, the experiments of Becker and Day on the linear force of growing crystals were cited as indicating the stability of a crystal in its solution, even when subjected to pressure. In their experiments loaded crystals were found to lift the load during growth, although the pressures on the supporting edges of the crystals were finally of the order of magnitude of the crushing strength of the crystal.

Discussion. The three papers were discussed by Messrs. Briggs, Buckingham, Hostetter, Sosman, and Williamson. Mr. Hostetter remarked that the reason for the effect of hydrostatic pressure on melting and solubility was much more obvious than that for the similar effect due to strain in the solid only, as hydrostatic pressure directly aids or opposes the volume changes accompanying such change in state. Mr. Buckingham referred to the complications introduced by the change in cross section of a crystal under load as it dissolves.

Correction. In the minutes of the 780th meeting, this Journal, **7**: 24. 1917, for "Messrs. Ferner and Rothermel were appointed tellers," read, "Messrs. Fenner and Rothermel were appointed tellers."

D. H. Sweet, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 311th meeting was held in the lecture room of the Cosmos Club on November 22, 1916.

INFORMAL COMMUNICATION

T. W. Stanton: *A Cretaceous volcanic ash bed on the Great Plains in North Dakota.* Near Linton, North Dakota, in the southern part of the State about 15 miles east of the Missouri River, there are several conspicuous white outcrops that at a distance suggest chalk or diatomaceous earth. At one of the best exposures, 1 mile southeast of Lin-

ton, the measured thickness of the white bed is 26 feet, and it lies in the Fox Hills sandstone about 35 feet above the top of the Pierre shale. The rock is very fine-grained and mostly massive, though it contains some thin-bedded layers. A sample of it has been examined by Dr. G. F. Loughlin, who finds that it "consists of 80 per cent of volcanic glass, 15 per cent of quartz and feldspar, 2 or 3 per cent of biotite (somewhat bleached) and scattered grains of calcite, hornblende, magnetite, and chlorite."

No fossils were found in the white ash bed itself, but in the sandstone directly overlying it distinctive Fox Hills invertebrates were collected at several horizons distributed through a total thickness of about 100 feet. A fossiliferous green band colored by greenalite, which lies 16 feet above the white bed, also contains a considerable amount of volcanic glass, thus showing that volcanic material is not restricted to the white ash bed.

This seems to be the first recorded observation of such a bed of volcanic ash in the Cretaceous sediments of the Great Plains. The nature and location of the deposit are such that its material must have been carried a long distance in the air and finally deposited in the sea. The nearest probable source, according to present knowledge of Cretaceous volcanism in the Rocky Mountains, is in the Livingston region, Montana, about 500 miles west. Remnants of this great ash shower should occur in other parts of the Great Plains and Rocky Mountains, and when recognized and identified they should be of some service in the definite correlation of local sections.

REGULAR PROGRAM

HENRY M. EAKIN: *The Quaternary history of central Alaska.* Central Alaska is rather evenly divided between uplands that are formed by solid rocks, and a number of basins floored with Quaternary sediments that head far inland and extend, apparently without interruption, to the sea. These basins seem to be interpreted properly as pre-Quaternary erosional depressions. The physical aspects of the region indicate that in Quaternary time the normal drainage outlets of these basins were temporarily dammed, large areas were inundated and silted up, new outlets through low passes in the rims of the old basins were formed, and the drainage of the whole region was reorganized. Various hypotheses as to the nature of the dams have been considered, including crustal warping, lava flows, gravel deposits, and glacier extension across the old basins.

The hypothesis that glaciers were the agents meets the requirements that the dams were formed simultaneously in widely separated localities and were transient. For two major stream diversions and for many minor ones ice damming seems clearly indicated, and no item of positive evidence antagonistic to this hypothesis has been discovered. However, complete knowledge of certain areas essential to the final solution of the problem is still lacking.

J. S. Diller: *Was the new lava from Lassen Peak viscous at the time of its eruption?* That it was viscous is indicated by the following considerations:

1. The material that rose from the volcanic chimney into the crater on the summit of Lassen Peak spread in all directions and filled the funnel-shaped crater to its rim, forming a lid to the volcano.
2. Upon reaching the crest of the crater's rim the lava overflowed at the lowest points, one stream flowing down the western slope of the peak and another toward Lost Creek on the northeast.
3. The flow down the west slope is about 1000 feet in length and is a normal stream of siliceous lava with very rough broken surface. That it was a hot, viscous mass beneath the surface at the time of its eruption is proved by the written testimony of a number of observers, who from 9.30 to 11.30 on the night of May 19, 1915, watched the glow and flashes of light from the flowing, breaking lava as, in plain view, it crossed the crater rim and descended the slope.
4. In the overflow stream at the head of Lost Creek the delicate, steam-torn lava was bent and folded, as if viscous, while advancing across the crater rim, and much of it was carried away by the tremendous blast of hot gas (from beneath the lid) that devastated the Hat Creek country.
5. When the hot blast escaped from beneath the lava lid a portion of the lid, apparently where hottest, subsided into the former crater and exposed a number of fracture surfaces of lava blocks. On some of these surfaces there are distinct lines of viscous flow, and as the surfaces originated during the subsidence following the great eruption in May, 1915, the lava must have been viscous at that time.

G. W. Stose: *Age of certain shales in Cumberland-Lebanon Valley, Pennsylvania.* The shales referred to are in detached areas in the limestone valley. The limestones range in age from Lower Cambrian to Ordovician and may be divided into seven formations. The shales were regarded by the Pennsylvania Geological Survey as equivalent to the shales formerly called Hudson River but now called Martinsburg, which overlie the limestones and adjoin them on the northwest. In weathered outcrop the various shales are closely similar and, as east of Harrisburg they have been brought together like parts of the same formation, this miscorrelation is not surprising.

The real age of the shales in the detached areas was determined only after tracing the seven formations of the limestone from their known outcrops in the Carlisle quadrangle, southwest of Harrisburg. The largest area of the shales south of Harrisburg was proved, by its relation to the Elbrook limestone, to be the Waynesboro shale of Middle Cambrian age, and typical purple siliceous shale of the Waynesboro was later found in it. The irregular relations to other formations on its north side are due to overthrust faulting, which terminates the area against the Martinsburg shale east of Harrisburg. The Waynesboro shale occurs also in prominent hills east of Schaefferstown and in small hills near Shillington, southwest of Reading. The shale thins abruptly

toward the east and north and is not visible on the north side of North Mountain, where it is probably present, although thin and covered with wash. Its greater thickness at Schaefferstown and south of Harrisburg is probably due to the fact that at these localities it is overthrust from farther south, where its thickness is greater.

Certain rocks at the Cornwall mines south of Lebanon, Pennsylvania, which were regarded as Hudson River shales by the Pennsylvania Geological Survey, were found to be metamorphosed siliceous banded limestones of the Conococheague limestone of Upper Cambrian age.

T. Wayland Vaughan: *Significance of reef coral fauna at Carrizo Creek, Imperial County, California.* Owing to the lateness of the hour this paper was postponed to another meeting.

At the 312th meeting, held December 20, 1916, the presidential address was delivered by the retiring President, Arthur C. Spencer: *Stream terraces in the Rocky Mountain province* (Illustrated). The address will be published at a later date.

At the twenty-fourth annual meeting held on the same evening the following officers were elected for the ensuing year: *President*, Walter C. Mendenhall; *Vice-Presidents*, Frank H. Knowlton and Arthur L. Day; *Secretaries*, H. E. Merwin and Esper S. Larsen, Jr.; *Treasurer*, B. L. Johnson; *Members-at-large-of-the-Council*, B. S. Butler, H. S. Gale, C. W. Gilmore, R. W. Pack, and L. W. Stephenson.

Carroll H. Wegemann, *Secretary*.

THE BOTANICAL SOCIETY OF WASHINGTON

The 116th regular meeting of The Botanical Society of Washington was held in the assembly hall of the Cosmos Club at 8.00 p.m., Tuesday, December 5, 1916, President T. H. Kearney presiding.

The program of the evening consisted of a symposium on the behavior of hybrids in different groups of plants.

Mr. G. N. Collins discussed the behavior of Indian corn. In about 25 cases out of 50 where the vigor of first-generation hybrids had been compared with that of the parents, definite evidence of greater vigor was secured, and in no instance was there clear evidence of decreased vigor. It was suggested that the differences in the degree of vigor observed in different varietal combinations appeared to be influenced by the length of time the parental strains have been isolated. Strains which are widely separated geographically, and on this account probably have been kept distinct for long periods of time, usually exhibit the greatest increase in vigor when crossed, while strains from the same or adjacent regions, although they may show more marked morphological differences, generally show a less marked increase in vigor in the first generation of the cross.

In a cross between two varieties having many sharply contrasting characters, a comparison of the variability of the first and second gen-

erations showed two characters where the first generation was more variable than the second, six characters in which the second generation was more variable than the first, and eleven characters in which there was no measurable difference. In the same cross, in correlation studies involving eleven contrasted characters with fifty-five possibilities of correlation, twenty cases of correlation were observed. All but five of these correlations, however, appear to be physical or physiological in their nature rather than genetic, such as the correlation between branching space and number of branches.

There are but few alternative or discontinuous characters in maize, and most of these are color differences or differences in chemical composition, as in the endosperm characters.

The discontinuous characters are for the most part Mendelian. Horny or sweet endosperm is perhaps the best example of a simple Mendelian character pair thus far encountered in maize. Horny and waxy endosperm are completely alternative, but there are definite departures from the expected ratios. Aleurone and endosperm color show all gradation between Mendelian monohybrid ratios and continuous inheritance.

Mr. O. F. Cook called attention to differences in behavior of different kinds of plants and animals, as indicating a possibility that the expectation of finding general laws applicable to the whole organic world may not be realized. Each case must be treated in a specific way. Increased vigor in the first generation is one of the more general phenomena attending hybridization. In cotton, for example, when distinct types are crossed, there is usually evidence of increased vigor and hardiness. These are expressed in larger size, better yield, and a greater ability to withstand adverse conditions. By distinct types of cotton are meant types which have a range comparable to the more divergent races of men, or to the Indian zebu as distinguished from our domestic races of cattle. The cotton types appear much more divergent than the types of corn.

The discussion was largely confined to examples in hybridization of cotton. As a rule the conjugate or F_1 generation is intermediate between the parents, while splitting is pronounced in the second and later generations but with no cases of complete return to either ancestral type. As a rule there is a great deal of correlation or coherence in the characters shown in the perjugate (F_2 and subsequent) generations. It has not been possible to secure a cotton combining in stable form the Upland type of vegetation and the Sea Island or Egyptian type of lint. Plants which resemble the Upland type have lint with the Upland characters and vice versa, but the plants that most nearly resemble the parental types in other respects are usually very inferior with respect to abundance and quality of lint.

Thus, one of the results of hybridization may be described as a total loss of the increment of selection which had been developed in the parent stocks previous to crossing. Some characters are more or less discontinuous, but others appear to be continuous. The opportunities for

selection in the conjugate generation are not good, on account of the general uniformity of the plants. Selections have been carried in some cases as far as 12 generations without securing evidences of stable combinations of desirable characters. Hybrids between Sea Island and Upland varieties were not so good as the better class of long-staple Upland varieties, when work with the hybrids was discontinued.

Mr. H. V. HARLAN discussed the behavior of barley hybrids. He first called attention to the strikingly different characteristics of the barley group and the sharply contrasting characters such as naked and hulled grain, black, purple, blue, or white colors, two and six-rowed, awned and hooded heads, smooth and toothed awns, etc. Individuals of the F_1 generation in barley either may be intermediate in character or may resemble one of the parents, and are quite uniform. In most of these crosses the characters are inherited in a 3 : 1 ratio. The substitution of hoods in the place of the awn, which has a very decided effect upon the physiology of the plant, is dominant to the presence of awns. The smoothness or roughness of the awns behaves as a Mendelian character. There is also a correlation between the smoothness of the awn and the hairiness of the stigma. Crossing between the two-rowed and six-rowed barley often results in an intermediate variety. Such characters as the following: hulled and naked, black and white, hooded and awned, are inherited in the 1:3 ratio. Fertility does not necessarily follow the 1:3 ratio.

Dr. C. E. LEIGHTY discussed hybridization in wheat varieties and species. Nine groups are available for hybridization: *Triticum monococcum*, *Triticum polonicum*, wild wheat of Palestine, and six subspecies of *Triticum sativum*. All of these species and subspecies hybridize and fertile hybrids have been obtained, rarely, however, between *Triticum monococcum* and any other group. Wheat and rye hybrids have been secured always by using wheat as the female parent. *Aegilops ovata* and *triticoides* have also been used in hybridization with wheat. The first generation shows increased vigor, so far as noted, and great uniformity. Most of the characters, however, are intermediate. When wild wheat is used in hybridization the spikelets of the hybrid fall apart as does the wild wheat. In the second generation segregation of most characters occurs in a 3: 1 or 1: 2: 1 ratio, but in some cases the ratio may be 15 : 1 or otherwise, as when a club wheat and wheat with tapering head are crossed. In most cases the behavior can be explained on the basis of Mendel's law. Wheat hybrids are often fixed and many of the good commercial strains have originated in this way. No bud variations or mutations have been noted.

Mr. J. B. NORTON discussed the crosses which he and Mr. A. D. SHAMEL had made between wheat and rye. Wheat is always used as the mother parent, as rye refuses to set seed with foreign pollen. The first generation plants show great vigor, and though they resemble the mother at first, at blooming time the resemblance to rye increases until they would normally be mistaken for that plant. The hybrids are nearly sterile, as out of thousands of first generation flowers only three

produced viable seed, the plants from which were accidentally lost. In hybrids between tobacco varieties first generation uniformity and vigor are noticed in a marked degree.

In the case of oat hybrids Mr. Norton noted that the segregation in the second and later generations was normally Mendelian, though in one or two cases intermediate forms became fixed. There is a distinct coherence of characters shown when naked oats are crossed with the ordinary hulled type. Naked oats have more than three grains to the spikelet, while in hulled oats the spikelets are limited to two or three. The first generation gives a peculiar intermediate, while in the second the parent types reappear with the intermediates in a 1:2:1 ratio, showing complete coherence of the two pairs of characters. While this coherence has not been split, two strains of the intermediate type were fixed.

Of asparagus hybrids a peculiar case was mentioned. *Asparagus davuricus*, a Chinese species, when crossed with pollen of *Asparagus officinalis* gave a progeny that resembled in most characters the *A. davuricus* mother, with the exception of a greater vigor. The first generation plants dropped their branches in the fall like *A. davuricus*. These hybrids were crossed back with *A. officinalis*, but the second generation showed none of the abcission phenomena exhibited by their mother parent, although the expected ratio was 1 : 1. One of the first generation plants of this cross shows a vine-like habit, a character not present in either parent or in any close relative, although vining is common in other sections of the genus.

Dr. W. A. Orton discussed the behavior of disease resistance in hybrids, with special reference to the wilt diseases of cotton, okra, watermelons, and cowpeas, caused by the well-known vascular parasite belonging to the genus Fusarium.

In cotton, resistance which occurs in rare individuals is separated out by selection, and the crosses discussed were made between such resistant strains and other varieties of Upland cotton.

Certain conditions impair the exactness of results with reference to Mendelian ratios. The strains used were not of pure type and the most resistant show some disease; uniform exposure to infection is secured with difficulty; the severity of the disease varies with weather conditions. Susceptible plants are killed and their progeny are not available for further study.

In the first generation in cotton hybrids wilt-resistance is dominant, only a small percentage showing disease, usually less than that of the resistant parent. In the second generation there is a segregation of the wilt-resistant character and a large percentage of non-resistant plants are produced. In reciprocal crosses an effect from the female parent is apparent in the second generation. By selection from the resistant plants the selected third generation shows a marked increase in resistance.

In the cowpea wilt-resistance seems to be limited to a distinct variety, the Iron. In the first generation of crosses with other varieties wilt-

resistance is dominant. In the second generation about one-third of the plants were sterile, the percentage being as high as 73 in some hybrids. About 67 per cent of the plants were seed producing.

In the case of the watermelon, the citron or stock melon was used in breeding for a disease-resistant variety. In the first generation increased vigor was very noticeable, and in the second generation characters were noted which had not been noted before in either of the parents, particularly in the colors of the fruits, and also in a bitter taste not noted in either of the parents.

Mr. W. J. Morse called attention to the behavior of hybrids in the soy bean, in which group study was made of the following characters: (1) flowers (white, purple); (2) pubescence (white, tawny); (3) seed (yellow, green, brown, black, bicolored); (4) cotyledons (yellow, green); (5) hypocotyl (green, purple); (6) smoothness; and (7) non-shattering. All of these are found to behave as Mendelian characters and to segregate according to Mendelian ratio. The only interrelation of characters noted is between the flower and the hypocotyl, the white flower being associated with the green hypocotyl and the purple flower with the purple hypocotyl. The non-shattering character is held to be one of the most important, and hybrids with this character have been fixed. Further work on this character with the standard commercial varieties is in progress. In the course of the hybrid work numerous sterile plants have been found. Natural hybrids of F_1 generation can usually be told in the field by the plants having a few smooth pods at the tip of the branches.

With the cowpea a large number of crosses have been made between the different commercial sorts, seeking to combine desirable characters. A study of the seed colors shows them to segregate in Mendelian ratio. Wilt and nematode resistance have been fixed in hybrids.

In the case of alfalfa, when hybrids of tender forms of *Medicago sativa*, such as Peruvian alfalfa, are made with *Medicago falcata* and the offspring subjected to severe winter conditions, there appears to be no tendency toward the elimination of the blue or purple-flowered forms, indicating that flower color is not particularly correlated with characters resulting in hardiness. There have been several crosses reported between rather distantly related species of Medicago, but it is believed that most of them are not true hybrids. It is believed that the *Medicago sativa* × *prostrata* hybrid is the only authentic one in the genus Medicago outside of the forms which Urban lists in his classification under *Medicago sativa*, which include *Medicago falcata* and *M. glandulosa*.

Mr. Walter T. Swingle called attention to the great difference in the behavior of Citrus from other groups mentioned, in that a larger amount of variability occurred in the first generation of the hybrids. In Citrus many of these first generation hybrids are of commercial value and may be propagated without variation from seeds which contain usually only false embryos originating from the nucellar tissue of the mother plant. For example, hybrids secured between *Poncirus trifoliata* and the common orange, *Citrus sinensis*, are sterile, notwith-

standing which they produce an abundance of seeds. These seeds originate parthenogenetically and represent a pure strain of the female parent. But in some few cases there is a true second generation. The individuals of the first generation vary greatly. The fruit may be smaller than that of either parent, or larger than the combined fruits of the two parents; it may be smooth or hairy, lemon-colored or orange-colored, with a great profusion of oil glands or almost without any; the shape of the tree may vary; the leaves are often 5-foliolate, although one parent is unifoliolate and the other always 3-foliolate. There is a very considerable cohesion of characters in the second generation of Citrus-Poncirus hybrids. It seems all but impossible, however, to secure hardiness and an orange flavored fruit at the same time. In the case of Citrus-Poncirus hybrids great vigor is observed in the first generation. If this first generation is crossed with a kumquat, increased vigor also is shown; but no increase in vigor results from the return cross between the first generation and the parental species. The kumquat belongs to a distinct genus, Fortunella, so that in crossing a citrange with a kumquat a trigeneric hybrid is produced, combining Citrus and Poncirus with Fortunella. Although the kumquat is a dwarf plant, its diversity from Citrus and Poncirus is so great that when crossed with a citrange it brings about greatly increased vigor. By crossing *Poncirus trifoliata* with the ordinary orange, and then crossing this first generation hybrid with the kumquat, a fruit somewhat resembling the lime has been produced; it has no direct genetic relationship with the latter, however.

During the general discussion Mr. L. C. CORBETT and Prof. WILLIAM STUART discussed the behavior of carnation hybrids, and the latter called attention to the desirability of securing as high a percentage of germination as possible in the second generation, in order that no selective error be introduced into percentage determinations. Mr. NORTON said that of several thousand cases of carnations grown from commercial types, the percentage of singles never was higher than 23 per cent.

H. L. SHANTZ, *Corresponding Secretary.*

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, February 6: The Botanical Society, at the Cosmos Club, at 8 p.m. The program will consist of a symposium: *The relation of plant succession to forestry and grazing.* Speakers: J. V. Hoffman, G. G. Bates, Arthur W. Sampson, and E. O. Wooton.

Tuesday, February 6: The Anthropological Society, at the Public Library, at 8 p.m. Program:

J. Walter Fewkes: *Prehistoric ruins in the Mesa Verde National Park.*

Tuesday, February 6: The Society of Engineers, at Rauscher's, 1034 Connecticut Ave. N. W., at 8 p.m.

Wednesday, February 7: The Medical Society, at the Medical Department of George Washington University, 1325 H Street N. W., at 8 p.m.

Thursday, February 8: The Chemical Society, at the Cosmos Club, at 8 p.m.

Saturday, February 10: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, February 14: The Geological Society, at the Cosmos Club, at 8 p.m.

Wednesday, February 14: The Medical Society, at the Medical Department of George Washington University, 1325 H Street N. W., at 8 p.m.

Saturday, February 17: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

H. Bateman (by invitation): *The nature of chemical forces.* 30 minutes.

L. B. Loeb: *The electron theory of valence.* 30 minutes.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh day of each month.

CONTENTS

ORIGINAL PAPERS

Page

Physics.—Standard substances for the calibration of viscometers. EUGENE C. BINGHAM and RICHARD F. JACKSON.......... 53

Chemistry.—Some problems of the oxides of iron. ROBERT B. SOSMAN.... 55

Geology.—Note on the diffusion of sodium chloride in Appalachian oil-field waters. G. B. RICHARDSON.......... 73

ABSTRACTS

Geology.......... 75

PROCEEDINGS

The Philosophical Society.......... 79

The Geological Society.......... 80

The Botanical Society.......... 82

Vol. VII

February 19, 1917

No. 4

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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* Volume I, however, from July 19, 1911 to December 19, 1911, will be sent for $3.00. Special rates are given to members of scientific societies affiliated with the Academy.

THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII FEBRUARY 19, 1917 No. 4

BIOPHYSICS.—*The living plant as a physical system.*[1] Lyman J. Briggs, Bureau of Plant Industry.

In early investigations relating to the growth of plants, the conception of a so-called "vital force" was frequently employed in the interpretation of the observed phenomena. It was long held, for example, that the organic substances found in plants and animals were dependent in their formation upon the existence of vital forces, and that in consequence such products could not be produced in the laboratory. The classical discovery of Wöhler that urea could be synthesized in the laboratory revolutionized the conception that *all* animal and plant products are dependent upon some vital force for their production. Since that time many other organic substances found in or derived from plants have been prepared synthetically. Many other phenomena associated with plant growth and formerly attributed to the existence of some peculiar vital force have through modern methods of investigation been satisfactorily explained from physico-chemical considerations. Until matter in that state which we term "living" can be synthesized, the doctrine of vitalism can scarcely be said to have been disproved; but it is surely being restricted more and more as our knowledge of plant phenomena increases. The situation at present may perhaps be fairly summarized as follows: The mechanism of plant processes

[1] Address of the retiring President of the Philosophical Society of Washington, presented before the Society January 19, 1917.

not at present explainable on a physico-chemical basis would be termed by the vitalistic school as "vital;" by the physico-chemical school, "unknown."

The efficiency of plant systems. I shall ask you in what follows to consider the plant from the point of view of a physical system, a system which is absorbing energy and performing useful work. Radiant energy is absorbed by this system from the sun and sky, and under some conditions heat is absorbed from the surrounding air as well. This energy is used to do work upon water and nutrients taken in through the roots and upon carbon dioxide absorbed through the leaves. A part of the energy, through the agency of remarkable catalyzing substances—the chlorophyll bodies and the protoplasm—is employed in the transformation of the materials absorbed into plant tissue. The latter represents the useful work performed by the system, which may be quantitatively determined by measuring the heat of combustion of the total plant substance formed. The remainder of the absorbed energy is spent in lifting and vaporizing water, except in those cases where the temperature of the plant rises above that of the surrounding air. In such instances heat energy is also transferred to the air.

Let us for the present assume that the temperature of the plant does not exceed that of the air, an assumption which leaf temperature measurements have shown to be amply justified in the case of actively growing plants in a dry atmosphere. The total energy used by the system in a given time will then be represented by the total heat equivalent of the water evaporated, plus the total heat of combustion of the plant substance developed during this period. If we represent the former by Q_e and the latter Q_c, both expressed in gram-calories, the efficiency (E) of the system may be represented by the relation

$$E = \frac{Q_c}{Q_e + Q_c} \tag{1}$$

Both quantities are capable of direct measurement. The water evaporated can be determined by means of suitably controlled field experiments designed to prevent all loss of water

except that taking place through the leaves, while the heat of combustion may be found by finally burning in a bomb calorimeter a representative sample of the plant substance produced.

Numerous investigations have been made of the water requirement of plants, i.e., the ratio of the weight of water absorbed by the plant during its growth period to the weight of dry matter produced. It will accordingly be convenient to transform our efficiency equation to include this term. If a mass M_w of water is transpired in the production of a mass M_p of plant tissue, and if h_v and h_c represent the heat of vaporization of water and the heat of combustion per gram of plant substance respectively, then

$$Q_e = M_w h_v \tag{2}$$

$$Q_c = M_p h_c \tag{3}$$

Substituting these quantities in equation (1) and remembering that M_w/M_p is by definition the water requirement R_w, we have

$$E = \frac{1}{\frac{h_v}{h_c} R_w + 1} \tag{4}$$

Determinations of the heat of combustion of the dry matter of various plants do not appear to have been made. In the absence of more specific data, we may assume the heat of combustion to be represented approximately by that of cellulose, namely, 4200 gram-calories per gram. By substituting this value together with that of the heat of vaporization of water (536 gram-calories per gram) in equation (4) we have as a first approximation to the efficiency of the plant system

$$E = \frac{1}{0.13\, R_w + 1} \tag{5}$$

The water requirement of field crops in the Great Plains as measured by Dr. H. L. Shantz and the writer ranges from 200 to 1000, depending upon the species and the evaporation-rate.[3]

[3] BRIGGS, L. J., and SHANTZ, H. L. *Relative water requirement of plants.* Journ. Agr. Research, 3: 1–63. 1914.

The lowest water requirement so far observed in the case of a field crop was obtained at Arlington, Virginia, in 1915, where corn and sorghum gave values of 151 $\pm$ 2 and 150 $\pm$ 2 respectively. If we substitute these values in equation (5) we find that the efficiency of the plants with the lowest water requirement so far measured is only about 5 per cent, while in the case of plants with a water requirement of 1000, the efficiency is less than 1 per cent. In other words, the fuel value of the plant, i.e., the potential energy stored in the plant substance, represents only from 1 to 5 per cent of the energy dissipated during the growth of the plant.

Since the efficiency is approximately inversely proportional to the water requirement it is of interest to consider briefly how the latter may be reduced. Two procedures are open, namely, plant selection and reduction in the evaporation rate. Different species of plants under the same environment show wide differences in water requirement. For example, Shantz and the writer have found the water requirement of alfalfa to be approximately three times that of millet, when the two species are grown in large pots side by side. It is thus evident that in a region where the rainfall is the limiting factor in plant production, the fuel value of the plant material produced will vary widely according to the water requirement of the plant. It would be of much interest in this connection to know something of the efficiency of different forest trees, but no water requirement measurements of such plants are yet available.

The second means of reducing the water requirement consists in the selection of habitats where the evaporation-rate is low. Here again little is known quantitatively as to what extent the efficiency may be increased in this way, and the subject affords a wide field for exploration. It is evident that if the absorption of water from the soil is so far reduced by increasing the humidity that the plant receives an inadequate supply of nutrients from the soil, growth would be retarded from this cause. Again, if we reduce the energy dissipated in evaporation by shading the plants, a limit will be set by the minimum quantity of radiant energy necessary for the photosynthetic processes.

The growth-rate. We pass now to the consideration of our plant system from the standpoint of the growth-rate. The plant system is remarkable in that the useful work done is expended in increasing the size of the system, at least during the earlier stages of growth. Furthermore, the quantity of catalyzer available for transforming the absorbed substances also increases with the size of the system. Therefore, while the efficiency of the system may not change during the growth of the plant, the quantity of useful work which it is capable of doing may theoretically increase at a rate proportional to the size of the system, assuming that an adequate supply of the products used in synthesis, i.e., carbon-dioxide, water, and nutrients from the soil, are present. This hypothesis is equivalent to saying that the rate of change of the weight m of the plant system is proportional to the weight itself, or, put into mathematical form:

$$\frac{dm}{dt} = a_1 m \tag{6}$$

Let us now see how nearly this assumption may be realized in nature.

Since it is not possible to determine directly the dry weight m without destroying the plant, we must have recourse to some indirect means of determining the mass of material present at any time. We shall, therefore, make a further assumption that the increase in size of the plant from day to day is accompanied by a corresponding increase in the quantity of water which it transpires, a quantity which as we have seen is readily measured. This latter quantity, however, would obviously depend upon the weather of each day, so that we must either maintain the plant under constant conditions from day to day during the course of the experiment, or we must correct the transpiration in accordance with the intensity of the weather factors each day. The latter procedure is the one which we have actually employed. This correction may be made in a simple manner by dividing the observed transpiration during a day by the observed evaporation from a shallow blackened tank for the corresponding day. This gives us a series of numbers which are proportional

to the transpiration or water loss from the plant during a series of uniform days, providing transpiration and evaporation are influenced in the same way by the changes in the weather. Our problem then is to determine how the transpiration corrected to the basis of uniform days varies with the time, our assumption being that the daily transpiration is dependent upon and is a measure of the size of the plant.

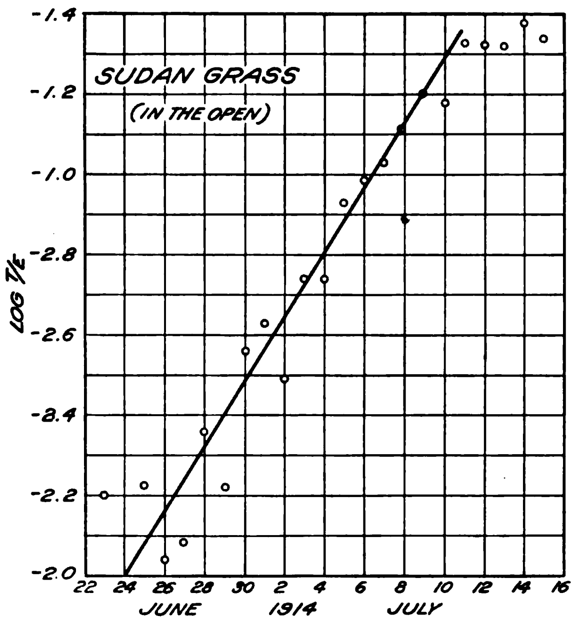

Fig. 1. Graph showing linear relationship between the logarithm of the transpiration-evaporation ratio of Sudan grass and the time. After Briggs and Shantz.

If now we return to our original hypothesis, that the rate of change in the size of the plant is proportional to the size of the plant itself, we will have by substituting the transpiration-evaporation ratio $\frac{T}{E} = k$ for the weight m of the plant in our original equation (6)

$$\frac{dk}{dt} = a_1 k \tag{6a}$$

Integrating this equation and transforming to common logarithms, we have

$$\log_{10}k = at + c \tag{7}$$

in which c is the logarithm of k when $t = 0$, that is at the be-

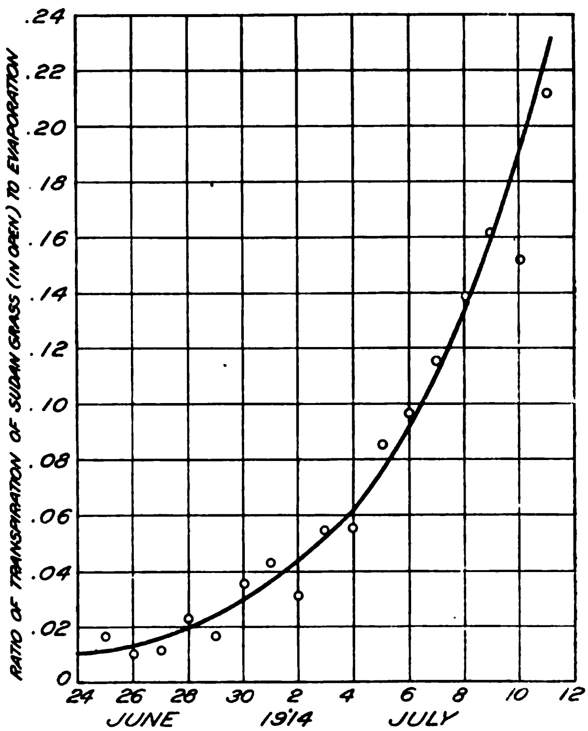

Fig. 2. Daily change in the ratio of transpiration to evaporation during early growth of Sudan grass. Circles represent observed ratios. Solid line computed from relationship in figure 1. After Briggs and Shantz.

ginning of the period under discussion. Expressing (7) exponentially, we have

$$k = 10^{at+c} = k_0 \cdot 10^{at} \tag{8}$$

Therefore, if the logarithms of the daily transpiration-evaporation ratio, when plotted against the time, form a straight line, the condition expressed in equation (6a) is satisfied, and the

plant increases in size in accordance with the compound interest law.

This method has been employed by Shantz and the writer in the examination of the daily transpiration of Sudan grass, corn, sorghum, and alfalfa.[3] The results indicate that during the early stages of the growth of these crops an approximately linear relationship does exist between the logarithm of the transpiration ratio and the time, as is shown in the case of Sudan grass in figure 1. In the case of alfalfa, this relationship held approximately up to the period of flowering. A comparison of the computed transpiration ratio (solid line) of Sudan grass with that actually observed (circles) is given in figure 2.

TABLE 1

RATE OF INCREASE IN THE TRANSPIRATION COEFFICIENT OF DIFFERENT CROPS IN 1914, ACCORDING TO BRIGGS AND SHANTZ

CROP	OBSERVATION PERIOD	(a)	DAILY RATE OF INCREASE	DAYS REQUIRED FOR k TO DOUBLE IN VALUE
			per cent	
Corn, Northwestern Dent	June 18–July 9	0.026	6.2	11.6
Corn, Algeria	June 18–July 11	0.044	10.7	6.8
Sorghum, Minnesota Amber	June 18–July 9	0.041	9.9	7.3
Sudan grass (in inclosure)	June 18–July 10	0.066	16.4	4.6
Sudan grass (in open)	June 24–July 11	0.082	20.8	3.7
Alfalfa, E23 (first crop in open)	June 16–July 10	0.033	7.9	9.1
Alfalfa, E23-20-52 (first crop)	June 19–July 9	0.037	8.9	8.1
Alfalfa, E23-20-52 (second crop)	July 18–Aug. 5	0.037	8.9	8.1

It is also possible to compute from the slope of the graphs the value of the exponent a in equation (8) and so to determine the daily rate of increase in the size of the plant. The results of such calculations for a number of plants are given in table 1. It will be seen that in the case of Sudan grass the plant system was doubling in size every four days, and in the case of alfalfa about every eight days.

Therefore during the early stages of growth the size of some of

[3] BRIGGS, L. J., and SHANTZ, H. L. *Daily transpiration during the normal growth period, and its correlation with the weather.* Journ. Agr. Research, 7: 155–212. 1916.

our common plants varies as an exponential function of the time, in so far at least as such changes in size are reflected by the change in transpiration through a series of uniform days. In other words the young plant confronted with the problem of maturing its seed and completing its life cycle before the advent of frost, proceeds to develop its system at the maximum possible rate consistent with the conditions, i.e., in accordance with the compound interest law. When an adequate leaf system is secured, the plant apparently turns its attention to the elaboration of material for seed production and the rate of increase in the size of the leaf system is modified. It is evident that any inhibiting factor, such as a limitation in the supply of water or of nutrient solution also would bring about the same result.

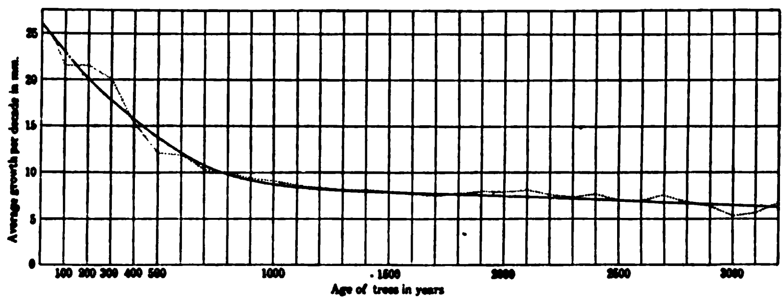

Fig. 3. Change in thickness of annual rings of Sequoia with the time. After Huntington.

Let us now turn from annual plants, which complete their life cycle in a few months, to the other extreme, and examine the rate of growth of the giants of the plant world, the Sequoias or big trees of California. Huntington[4] has recently made extensive measurements of the thickness of the annular rings of these trees with a view to determining to what extent the variation in thickness of these rings is correlated with fluctuations in the weather conditions during the life of the tree. His measurements showing the change in thickness of the ring as the tree grows older, based upon measurements of trees of varying ages up to

[4] Huntington, E. *The climatic factor as illustrated in arid America.* Carnegie Inst. of Washington, Pub. No. 192. 1914.

3200 years, are summarized graphically in figure 3. The dotted line in this figure connects the 100-year means, through which a smoothed graph has been drawn. If we assume the latter to represent the relation between the thickness of the rings and the age of the tree, we see that after the trees have reached an age of about 1200 years, the ring thickness $\frac{dr}{dt}$ is a linear function of the time, or

$$\frac{dr}{dt} = -at + b \tag{9}$$

Integrating this equation and evaluating the constants from figure 3, we have as the relation between the stump radius of the tree in millimeters and the time in years, starting with trees 1200 years old,

$$r = -0.00005t^2 + 0.83t + 1670 \tag{10}$$

From 1200 to 3200 years then the radius does not increase proportionally to the time, but is subject to a negative correction term varying as the square of the elapsed time.

The straight line portion of Huntington's graph (fig. 3) would if extrapolated cut the axis of abscissae at about 9000 years. It is more probable that the graph approaches the axis of abscissae asymptotically, since the straight line relationship would lead to a shrinkage after 9000 years. The relationship expressed in equation (*10*) must therefore be restricted practically to the period covered by the observations.

It is perhaps of more interest to consider the rate of growth of these old trees. In this connection let us determine how the tree would increase in diameter if a uniform quantity of woody tissue were laid down each year. We may for this purpose assume the stem of the tree to have the form of a right cone with a base radius r and height h, and we will also assume that the height of the cone increases in proportion to the radius. We may then look upon the growth each year as consisting of a thin layer or shell of thickness dr wrapped closely about the cone.

The volume V of the trunk of this idealized tree at any time would be

$$V = \tfrac{1}{3}\pi r^2 h \tag{11}$$

or, since by assumption $h = \alpha r$

$$V = \tfrac{1}{3}\pi \alpha r^3 \tag{12}$$

The rate of growth would be

$$\frac{dV}{dt} = \pi \alpha r^2 \frac{dr}{dt}, \tag{13}$$

hence the necessary condition for a uniform growth rate is that

$$\frac{dt}{dr} = cr^2 \tag{14}$$

where c is a constant.

Let us now examine Huntington's data for the Sequoia by plotting $\frac{dt}{dr}$ against r^2. If a portion of the resulting graph is a straight line, the growth-rate during the corresponding period will be constant, subject of course to the assumption made regarding the form of the tree. This graph is presented in figure 4. It will be seen that the growth-rate decreases for values of r^2 up to 30,000 cm^2, corresponding to trees about 1200 years of age. For values greater than this, however, the relationship is approximately linear, i.e., the growth-rate is constant within the errors of the determinations. The oldest trees included in these measurements were over 3000 years of age. Since the birth of Christ, therefore, these giant trees have been growing at a practically uniform rate, save as that rate has been modified by weather conditions.

Gas exchange between the leaf and the air. We pass now to a consideration of some of the physical processes within the plant. We shall first consider the path by which carbon dioxide enters the leaf. The rate of assimilation of carbon-dioxide by an active leaf in bright sunlight is very great. In fact Brown and Escombe have found that a Catalpa leaf in bright sunshine will absorb carbon-dioxide at a rate one-half as fast as it would if the lower surface of the leaf were covered with a film of caustic potash solution constantly renewed. The stomatal openings in the

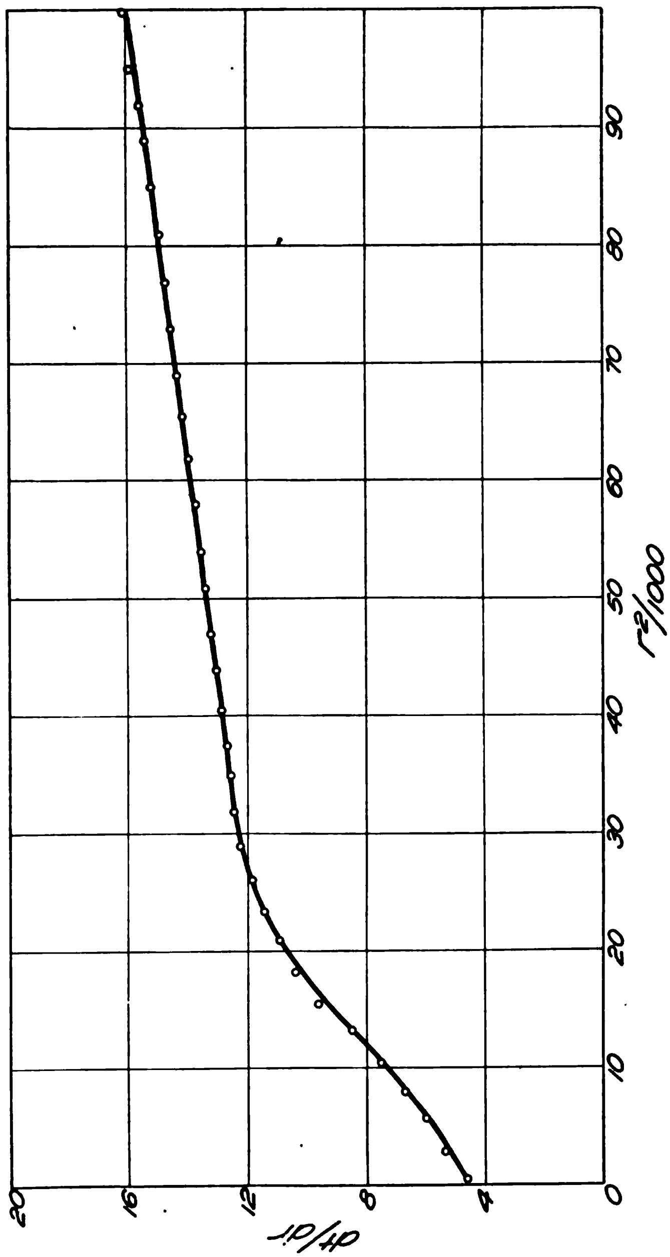

Fig. 4. Graph showing linear relationship between the square of the radius of old Sequoia trees and the reciprocal of the ring thickness, thus indicating a constant growth-rate during the corresponding period.

leaf are extremely minute and their total area is only about 1 per cent of the leaf area. How does the carbon-dioxide enter the leaf? Does the interchange of gas and water vapor between the leaves and the air take place by means of diffusion through the cuticle of the leaf? Or do the minute stomatal openings provide the means of entrance and exit?

The early experiments of Boussingault,[5] in which the rate of assimilation of carbon-dioxide by leaves having their stomata blocked with lard was compared with that of normal leaves, led to the conclusion that the absorption of carbon-dioxide by the leaf takes place by means of cuticular diffusion, and that the stomata play little or no part in the process. The cuticular diffusion hypothesis found favor also on account of the relatively large surface available for diffusion compared with the area of the stomatal openings.

Boussingault's experiments, however, were carried out in an atmosphere abnormally high in carbon dioxide, and in 1895, Blackman[6] showed that the relative amount of carbon dioxide assimilated by leaves with stomata blocked and free was dependent upon the carbon dioxide content of the air. When the carbon dioxide content was reduced to partial pressures corresponding more nearly with atmospheric conditions, an Oleander leaf with its stomata blocked showed a much lower assimilation of carbon dioxide than a similar leaf with open stomata. In other words, the high partial pressure of carbon dioxide in Boussingault's experiments resulted in a carbon dioxide poisoning of the leaf having open stomata, and a corresponding reduction in assimilation; whereas, in the case of the leaf with its stomata blocked, sufficient protection was afforded to permit assimilation to proceed normally. Blackman concluded that for partial pressures of carbon dioxide approaching that in the atmosphere, no appreciable diffusion through the cuticle of the leaf takes place.

[5] Boussingault, M. *Étude sur les fonctions des feuilles.* Agronomie, Chemie Agricole et Physiologie, **4**: 267–401. 1868.

[6] Blackman, F. F. *On the paths of gaseous exchange between aerial leaves and the atmosphere.* Phil. Trans., **186B**: 508–562. 1895.

Living plants in the dark slowly give off carbon dioxide as a respiration product, similar to animals. Blackman made use of this phenomenon in a further investigation of the function of the stomata. Two constant currents of air free from carbon dioxide were passed through capsules clamped to the leaf and made tight with wax seals, and the amount of carbon dioxide given up by the leaf determined. A summary of some of Blackman's measurements is presented in table 2. The first three plants are evergreens with a thick cuticle. The leaves of the other plants investigated are thin, and those of *Polygonum,* in particular, are extremely delicate. In all cases the stomata are

TABLE 2

RESPIRATION OF CO_2 IN CUBIC CENTIMETERS PER HOUR FROM UPPER AND LOWER SURFACES OF LEAVES HAVING STOMATA CONFINED TO LOWER SURFACES, ACCORDING TO BLACKMAN

PLANT	DEVELOPING LEAVES			MATURE LEAVES		
	Upper surface	Lower surface	Ratio	Upper surface	Lower surface	Ratio
Nerium oleander	0.001	0.147	$\frac{1}{100}$	0.002	0.078	$\frac{3}{100}$
Prunus laurocerasus	0.001	0.085	$\frac{2}{100}$	0.002	0.076	$\frac{3}{100}$
Hedera helix	0.001	0.075	$\frac{2}{100}$	0.002	0.054	$\frac{4}{100}$
Platanus occidentalis				0.001	0.05	$\frac{2}{100}$
Ampelopsis hederacea				0.003	0.10	$\frac{3}{100}$
Polygonum sacchalinense				0.002	0.03	$\frac{6}{100}$

confined to the under side of the leaf. Reference to the table will show that the respiration is confined almost wholly to the stomatal side of the leaf, the maximum respiration from the upper side being only 6 per cent of that from the lower and in most instances far less than this.

This capsule method was also employed by Blackman for investigating the relative rate of absorption of carbon dioxide by the two sides of the leaf. Air containing a known amount of carbon dioxide was passed through capsules provided with glass faces, the surface of the leaves being brightly illuminated. The air after traversing the capsules was analyzed for carbon dioxide. In this way, Blackman found that in the case of leaves

having their stomata all on the under side no carbon dioxide was taken up by the upper surface of the leaf even in direct sunshine. On the other hand, in the case of leaves with stomata on both sides, both the upper and the under side of the leaf were active in assimilation.

We have seen that according to Brown and Escombe, absorption of carbon dioxide by the under side of the Catalpa leaf proceeds about one-half as rapidly as it would if the leaf surface were covered with a constantly renewed film of caustic soda. If, then, the absorption of carbon dioxide takes place only through the stomata, the total area of which when fully opened is only

TABLE 3

DIFFUSION OF CARBON DIOXIDE THROUGH CIRCULAR APERTURES OF DIFFERENT DIAMETERS, ACCORDING TO BROWN AND ESCOMBE

NO.	DIAMETER OF APERTURE	CO_2 DIFFUSED PER HOUR	RATIO OF AREAS OF APERTURES	RATIO OF DIAMETERS OF APERTURES	RATIO OF CO_2 DIFFUSED IN UNIT TIME
	mm.	cc.			
(1)	22.70	0.23800	1.00	1.00	1.00
(2)	12.06	0.09280	0.28	0.53	0.39
(3)	12.06	0.10180	0.28	0.53	0.42
(4)	5.86	0.05558	0.066	0.25	0.23
(5)	6.03	0.06252	0.07	0.26	0.26
(6)	3.23	0.03988	0.023	0.14	0.16
(7)	3.22	0.03971	0.020	0.14	0.16
(8)	2.00	0.02397	0.007	0.088	0.10
(9)	2.12	0.02608	0.008	0.093	0.10

about 0.9 per cent of the area of the under side of the leaf, the rate of diffusion per unit area through these openings must be approximately 50 times the rate at which carbon dioxide is absorbed per unit area by a caustic soda solution of the same total area as the leaf.

Diffusion through perforate septa. It will at once be noted that the two systems just compared differ in one important respect. The absorbing surface presented by caustic soda solution is in the form of a single continuous surface. The stomatal system on the other hand is made up of minute elliptical openings separated by intervals from 5 to 10 times the diameter of the

stomata. Is the diffusion-rate through a multi-perforate septum of this kind sufficient to account for the rate at which carbon dioxide is absorbed by the leaf?

This problem was made the subject of an extensive investigation by Brown and Escombe[7] in 1900. The diffusion of carbon dioxide in cylinders partially filled wih caustic soda solutions was first studied. When such cylinders were exposed in still air it was found, as might be expected, that the amount of carbon dioxide diffusing down the cylinders in a given time varied directly as the cross-sectional area of the cylinders and inversely as their length. If, however, the diffusing tubes were partially closed at the top by septa with single circular openings of different diameters, the diffusion was found to be proportional, not to the areas of the apertures, but approximately to their radii. In other words, the diffusion through small isolated circular openings proceeds much more rapidly than would be indicated by the area of the opening. Some of the results obtained by Brown and Escombe, from which they developed the so-called diameter law controlling stomatal diffusion, are given in table 3.

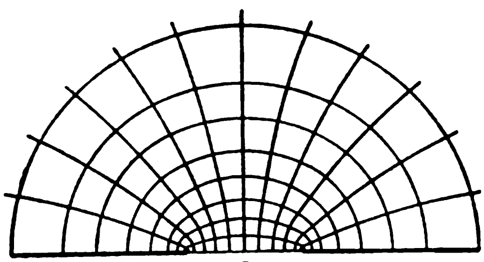

Fig. 5. Diffusion of carbon dioxide into a stomatal opening of a leaf surrounded by still air. The surfaces representing uniform partial pressures of CO_2 are ellipsoids, which are cut at right angles by the diffusion stream lines (hyperbolas). After Brown and Escombe.

Brown and Escombe call attention to the analogy between the diffusion system which they investigated and that of an electrified disk. The electrostatic capacity of such a disk may be shown from theoretical considerations to be proportional, not to the area of the disk, but to its diameter. The equipotential surfaces about such a disk (fig. 5) are ellipsoids having the edges

[7] Brown, H. T., and Escombe, F. *Static diffusion of gases and liquids in relation to the assimilation of carbon and translocation in plants.* Phil. Trans., **193B**: 223–291. 1900.

of the disk as foci; while the lines of force along which an electrified particle would move to the disk lie in the surfaces of hyperboloids which cut the ellipsoids at right angles and have their foci in the edges of the disk.

Consider the electrified disk to be replaced by a liquid film which absorbs carbon-dioxide perfectly and which is surrounded by still air. The ellipsoidal shells now become surfaces representing uniform concentrations of carbon-dioxide, and the hyperboloidal shells represent surfaces along which the carbon-dioxide molecules are streaming to the disk. It is evident that the rate of diffusion through the absorbing surface is far greater than for an equal area in free space; and if the electrostatic analogy holds, the diffusion in unit time would be proportional to the diameter of the disk, which is in accord with Brown and Escombe's results.

We pass now to the consideration of multi-perforate septa. It is evident that if the small openings through the septum were sufficiently close together, one aperture would modify the stream lines through another, and the diameter law would not hold. This matter was experimentally investigated by Brown and Escombe, using septa perforated with holes 0.38 mm. in diameter. They concluded that when the distance between the apertures is not less than ten times the diameter of an aperture, there is no interference in the diffusion through neighboring holes.

It remains to be seen how closely the rate of diffusion of carbon-dioxide into the leaf of a plant may be calculated from the diameter law, when the size and number of the stomatal openings are known. Such calculations as a matter of fact lead to values very much in excess of the actual quantity of carbon-dioxide taken in by a leaf, even when it is assimilating most actively. The maximum assimilation of carbon-dioxide by sunflower so far recorded amounts to only 5 to 6 per cent of the possible assimilation according to theory. This lack of agreement is ascribed by Brown and Escombe to the fact that the cells in the stomatal cavity are not perfect absorbers of carbon-dioxide; in other words that the partial pressure of carbon-dioxide at the surface of these cells is not reduced to zero as assumed in the

theoretical deductions. This explanation is not altogether satisfying and leads to the query whether the diameter law holds when extrapolated to the degree necessary to apply to the stomatal system. The smallest apertures used in the development of the diameter relationship was about 2 mm., whereas the diameter of the stomatal openings is of the order of 0.01 mm.

The rate of diffusion of water vapor outward through the stomatal opening affords a possible method for checking Brown and Escombe's deductions, which they do not appear to have employed. By observing the diffusion-rate of water vapor instead of carbon-dioxide the assumption regarding the imperfect absorption of carbon-dioxide would be avoided. The determination of the vapor pressure in the interior of the leaf would be necessary, but this could be made with a fair degree of accuracy by measuring the temperature of the leaf and the concentration of the cell contents.

It is of interest to consider in this connection the work of Buckingham[8] on the diffusion of carbon-dioxide through soils. He found experimentally that the rate of diffusion varied as the square of the porosity, the latter term denoting the volume of the interstitial space between the soil grains unoccupied by water, expressed in per cent of the total volume. He also tested this observed relationship by assuming all the soil grains to be removed, so that the porosity would be 100 per cent. This should lead to the velocity of free diffusion of carbon-dioxide in air, and Buckingham's empirical equation gave a result well in accord with previous determinations of free diffusion by other investigators. It will at once appear that this deduction departs widely from the diameter law of Brown and Escombe. If we consider a volume of soil of unit thickness, the porosity will be proportional to the integrated area of the interstitial spaces in any plane parallel to the surface. If we assume as a first approximation that the pores are uniform in cross-section, then the porosity would be equal to the product of the number of pores n and the cross-section a, or the diffusion

[8] BUCKINGHAM, E. *Contributions to our knowledge of the aeration of soils.* U. S. Dept. Agr., Bur. Soils Bulletin No. 25. 1904.

would be proportional to n^2a^2. According to Brown and Escombe the diffusion would be proportional to $n\sqrt{a}$. While it is evident that in this comparison we are not fulfilling one important condition imposed by Brown and Escombe, namely, that the pores shall be sufficiently far apart to avoid interference in the diffusion stream lines, the two conclusions are at such great variance as to invite a further examination of the diameter law.

The ascent of sap. We have to consider finally the means by which the water is lifted to the tops of the highest trees, amounting in the case of the Sequoia to a distance of 300 feet above the ground.

Strasburger,[9] by poisoning the cells of various plants, has shown that the living elements of the wood play no essential part in the elevation of the water. An oak nearly 22 meters high cut off obliquely at its base and set in a picric acid solution was found to take up the poisonous solution readily. After the acid had reached a height of 15 meters and the topmost leaves had changed markedly in appearance, fuchsin was added to the picric acid solution. At the end of nine days the highest branches were found to be impregnated with picric acid, which had been drawn up to a height of nearly 22 meters. Fuchsin also was found in these branches, although preceded by the picric acid by three days. This experiment, then, demonstrated that water solutions can rise in trees without the assistance of living cells to heights far above those that can be accounted for by atmospheric pressure. Strasburger also found that stems of plants killed by subjecting them to a temperature of 90°C. were still capable of raising water to a height of 10.5 meters. We may, therefore, conclude that vital processes are not essential to the ascent of sap.

Of the numerous theories which have been advanced in explanation of this phenomenon, that of Dixon and Joly[10] alone appears to be physically sound. According to these authors, sap rises through the trunk of the tree as the result of evapora-

[9] STRASBURGER, E. *Ueber das Saftsteigen.* Histol. Beitr., **5**: 10. 1893.

[10] DIXON, H. H., and JOLY, J. *On the ascent of sap.* Phil. Trans., **186B**: 563–576. 1895.

tion from cells communicating with the stomatal cavities of the leaf. The column is then, so to speak, hung from these leaf cells, and is supported by the adhesion of the water to the walls of these cells. We may consider the outer surfaces of these cells to be saturated with water, which retreats into the wall tissue in such a way as to form a great number of capillary surfaces of high curvature, this curvature in fact being such as would be necessary to support a capillary column of the observed height. If through the evaporation of water from the leaves the curvature tends to increase, the force exerted by these curved surfaces will increase proportionally, and additional water will be drawn from the soil, tending to restore the equilibrium.

It will at once be evident that this conception postulates that water must have great cohesion, sufficient in fact to withstand the weight of a column 300 feet or more in height. Since this is an essential condition of the theory, we may profitably consider the cohesion of water in more detail.

Berthelot[11] in 1850 showed that a column of water under suitable conditions can withstand a very great tensile stress. A strong capillary tube sealed at one end and drawn to a fine point at the other was filled with water at a temperature of 30°. The water was then cooled to 18° and the tube allowed to draw in air, after which the tube was sealed. The tube was now heated to 30° and the contained air was forced into solution, so that the water occupied the entire volume of the tube. On again cooling the tube to 18° it was found that the liquid continued to occupy the entire volume of the tube. To produce a compression equal to this observed dilatation would require a pressure of about 50 atmospheres, from which Berthelot concluded that a water column is capable, under suitable conditions, of withstanding a tensile stress of 50 atmospheres. Dixon, using Berthelot's method, has concluded that the cohesive force of water per unit cross-section amounts to at least 150 atmospheres. The water used in his experiments was saturated with air and also contained pieces of the conducting tracts of plants. The measure-

[11] BERTHELOT, M. *Sur quelques phénomènes de dilatation forcée des liquides.* Ann. Chem. et de Phys., **30**: 250. 1850.

ments were made through a series of temperatures ranging from 25° to 80°C.

Renner[12] and Ursprung[13] working independently, have recently used the annulus cells of the spore cases of fern as a means of measuring the cohesion of water. Both investigators find that the cell contents of many of the spore cases may be brought into equilibrium (through the vapor phase) with solutions having an osmotic pressure of 300 atmospheres before the limit of cohesion is reached and air bubbles appear in the cells. All of these experiments appear to support the conclusion that the cohesion of water is amply sufficient to withstand the stresses in the stem of a tree.

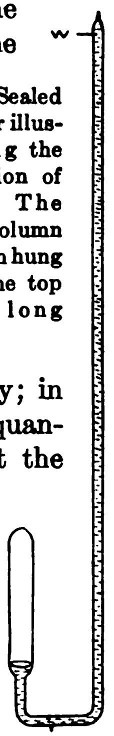

Fig. 6. Sealed tube for illustrating the cohesion of water. The water column is shown hung from the top of the long tube.

The cohesion of water may be easily demonstrated, as Dixon has shown, by means of a J-shaped sealed tube (fig. 6). A quantity of water more than sufficient to fill the lower limb is introduced into the tube, which is then partially exhausted and sealed off. It is unnecessary to reduce the air pressure below 2 cm. of mercury; in other words, the water may contain very appreciable quantities of air. If the tube is now first inclined so that the water fills the longer limb completely, which may be over a meter in length, and is then carefully raised to the position shown in figure 6, the water column remains hanging from the top of the tube. On destroying the cohesion of the column at some point by a sharp blow, or preferably by heating a stout platinum wire previously sealed through the wall of the tube for this purpose, the water column suddenly falls to the level determined by the gas pressure in the bulb.

Cohesion may also be readily demonstrated by a Bourdon spring connected with a bulb through a flexible capillary tube.

[12] Renner, O. *Theoretische und Experimentalles zur Kohäsionstheorie der Wasserbewegung.* Jahrb. Wiss. Bot., **56**: 617–667. 1915.

[13] Ursprung, A. *Ueber die Kohäsion des Wassers in Farnannulus.* Ber. Deutsch. Bot. Gesells., **33**: 153–162. 1915.

The system is completely filled with alcohol at room temperature and sealed. The spring with its index is placed under a bell-jar, which is then evacuated. On cooling the bulb, the spring will close somewhat, due to the internal stress set up by the contracting liquid. This stress may be demonstrated by heating the capillary locally, thus breaking the liquid column, when the spring will be observed to fly back suddenly to the unstressed position. The stress exerted by the liquid at the time may be found by determining the external pressure necessary to produce the same distortion of the spring.

The channels in the stem of a tree through which water is conducted are divided into minute compartments by means of numerous longitudinal and transverse partitions. This configuration seems ill adapted to the conduction of fluids; for while the walls are permeable to water, they offer a great resistance to its flow. But from the standpoint of the cohesion theory of the ascent of sap this structure becomes, as Dixon[14] has shown, a beautiful adaptation of the plant to confer stability on the tensilely stressed transpiration stream. The ascending column of water, interlaced by these innumerable permeable partitions, is given great stability even though subjected to great tensile stress.

Observers agree that air bubbles are of common occurrence in the water ducts of the stems of plants. It is evident from Dixon's experiments that dissolved air is not prejudicial to cohesion. But if a minute bubble appears in an experimental tube in which the water is subjected to great stress the bubble expands rapidly and the column is at once ruptured. How then can the presence of air in the conducting channels be harmonized with the cohesion theory of the rise of sap? Here the plant again shows in the minute subdivisions of its conducting channels a beautiful provision against the interruption of its water supply through the development of bubbles in the stem. If an air bubble appears in one of the minute compartments, it may expand, as Dixon has pointed out, until it fills the compartment,

[14] DIXON, H. H. *Transpiration and the ascent of sap.* Progressus Rei Botanicae, **3**: 1–66. 1909.

but beyond that it can not go. As the air follows the water back into the imbibing walls minute capillary surfaces of great curvature are developed, which successfully withstand the pressure of the gas from within, and what is far greater, the stresses from without. This compartment then simply becomes inoperative. The transpiration stream flows around it, as the waters of a river flow around an island in its center.

When the world's supply of coal and oil is exhausted, man will be reduced to the extremity of dependence upon solar engines, water power, and wood as sources of energy, unless his ingenuity has meantime been equal to the task of liberating the energy of the atom. So far as we can see at present, wood and plant products will then constitute, as in fact they do now, the only means of storing in a readily transportable form the energy received from the sun. Hence, efficiency in plant production from the standpoint of both food and fuel promises to be a problem of rapidly increasing importance as the years progress—a problem which demands for its complete solution the fullest possible understanding of the physical and chemical processes associated with plant growth.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 782nd meeting was held at the Cosmos Club, January 20, 1917. President BUCKINGHAM in the chair; 88 persons present. The minutes of the 781st meeting were read in abstract and approved.

The evening was devoted to hearing the address of the retiring President, Mr. LYMAN J. BRIGGS, on *The living plant as a physical system.* The address is published in this JOURNAL, **7**: 89–111. 1917.

DONALD H. SWEET, *Secretary.*

THE CHEMICAL SOCIETY OF WASHINGTON

The 260th meeting of the society was held at the Cosmos Club, April 13, 1916. Dr. C. L. PARSONS, Secretary of the American Chemical Society, presented announcements in relation to the Spring Meeting of the society at Urbana, Ill. and the projected work of the Naval Advisory Board in its attempt to inventory the resources of the country. Dr. Parsons represents the Chemical Society in this work in the District of Columbia. The following program was presented:

H. W. DAUDT, Bureau of Chemistry: *Investigations of the Kjeldahl method of determining nitrogen.*

The proper conditions for the complete decomposition of refractory compounds of nitrogen with acid ammonium sulphate were discussed. Mercuric oxide cannot be replaced by other catalysts, or potassium sulphate by sodium sulphate. The results of analyses of compounds of various constitutions were discussed.

A new aeration apparatus is devised for this determination. Folin's method for determining ammonia is adapted to the Kjeldahl method. All the operation, including the measurement and addition of the sodium hydroxide, the passing of air through the resulting alkaline solution, and the absorption of the ammonia in standard acid solution, are carried on by means of air pressure or suction. The advantages over the more commonly used distillation method were discussed. (Author's abstract.)

J. M. JOHNSON, Bureau of Chemistry: *A fourth pentacetate of galactose.*

In continuation of the work on the preparation of the various isomeric acetates of the sugars, carried out in conjunction with Hudson, a fourth crystalline pentacetate of galactose, having properties quite distinct from those of the three known isomers, has been isolated. An account of the method of preparation and properties was presented.

E. A. HILL, Patent Office: *Van't Hoff's principle of optical superposition. The lactonic constitution of the aldose sugars and the melasaccharins and the constants from which their specific rotatory powers can be computed.*

By a comparison of the experimental values with the values of the specific rotation computed on the basis of certain assumptions as to constitution and structure, it is shown:

1. That in carbohydrates and their derivatives having a plurality of asymmetric carbon atoms, more particularly the aldose sugars (provided we assume the modern γ-oxidic or lactonic ring theory of their structure), the specific rotation $[a]_d$ is the algebraic sum of certain constants corresponding to such asymmetric atoms so that, if A, α, β, γ, δ, etc., be the constants for a given group of active isomers, the specific rotation will be given by the formula;

$$[a]_d = \pm A \pm \alpha \pm \beta \pm \gamma \pm \delta \ldots$$

2. That Van't Hoff's so-called principle of optical superposition is therefore valid for these cases.
3. That the γ-oxidic or lactonic ring theory of these sugars, which has been used to explain the phenomenon of mutarotation, is thereby confirmed.

The agreement between observed and computed values is very satisfactory in each of the five groups presented. Thus, in both the aldopentose and aldohexose sugars the maximum difference does not exceed 1 per cent and the average difference is 0.1 per cent of the observed values.

The methods used for computing the constants are: 1st, a strictly algebraic method; 2nd, a method similar to that used by Dr. Hudson in computing his quantity A and which is as follows: When the structural formulas of two active isomers differ only in the configuration of one and the same asymmetric atom, the algebraic difference of their specific rotations will be twice the value of the constant of such atom.

The 261st meeting of the Society was held in the Assembly Hall of the Y. M. C. A. Building, May 11, 1916. Amendments to the constitution were adopted abolishing the office of first and second vice-presidents, the present incumbents to become members of the Executive Committee, the membership of which was increased to six elected members. Mr. F. C. COOK was elected member of the Executive Committee to succeed H. M. LOOMIS, retiring from the section. The following resolution presented by a special committee consisting of J. A. LECLERC, J. T. KEISTER, and H. S. BAILEY was adopted:

In the death of Prof. GEORGE E. PATRICK the Chemical Society of Washington has lost one of its oldest members. Professor Patrick was ever a faithful attendant at its meetings and frequently took an active part in the discussions.

He was a man of broad discernment and of high ideals, brave, yet unobtrusive. One of his most noble deeds was the gift of several thousand dollars to The University of Kansas, a large part of the yearly proceeds of which is to be presented to the student preparing the best essay on Applied Christianity.

The Chemical Society of Washington records with sorrow the death of their fellow member and hereby places this meager testimony of his worth in its minutes.

The following program consisting of papers from the Hygienic Laboratory was presented:

C. N. Myers: *The preparation of heavy metal salts of certain organic acids.*

An account of the methods of preparation and the properties of some of the less commonly known heavy metal salts of organic acids was given. These salts were prepared for use in such pharmacological investigations as are mentioned in the following abstract.

G. C. Lake: *Some observations on the toxicity and chemotherapy of the heavy metals.*

This paper is a brief report on work done, under the direction of Prof. Voegtlin, with the lactates and thioglycollates of nearly all the heavy metals. Toxicity was determined on rats and guinea pigs by several routes of injection, the dosage being based on actual content of metal, and given in mgs. per kg. of body weight. The action and pathology were studied to some extent. It was found that all are relatively toxic provided they enter the circulation. There seems to be no constant relation between toxicity and atomic weight of the metal or its position in the periodic system. The preparations were all studied in relation to their action on *Tr. Brucei* in vitro and in vivo, using rats and guinea pigs. The only preparation giving any marked trypanocidal action was an antimonial. The great specificity of drugs in regard to their chemotherapeutic action is again emphasized by this work. (Author's abstract.)

Elias Elvove: *The separation and determination of small amounts of antimony.*

Small amounts of antimony (less than 1 mg.) can be estimated by comparing the color produced by treating the unknown solution with hydrogen sulphide water, with the colors similarly produced in solutions containing known amounts of antimony. As little as one-hundredth of a milligram of antimony in 20 cc. can be detected by means of the hydrogen sulphide test. The antimony sulphide resulting from amounts of antimony up to about 0.1 mg. in 25 cc. remains in colloidal solution for an hour or two and thus admits of its colorimetric estimation. In the presence of arsenic and tin (up to 5 mg.) the arsenic is first separated as ammonium magnesium arsenate by the aid of the simultaneous phosphate precipitation of Smith (Bur. Chem. Cir. No. 102). The filtrate is boiled down to about 10 cc., cooled, made up to 15 cc. with water acidified with 1 cc. concentrated hydrochloric acid (Sp. gr. 1. 19) and boiled for two minutes. After cooling, it is diluted again to 15 cc. with water further acidified by adding 5 cc. of

concentrated hydrochloric acid, and then mixed with 5 cc. of a saturated solution of hydrogen sulphide. This concentration of hydrochloric acid serves to keep the tin in solution but does not prevent the antimony from reacting with the hydrogen sulphide. The antimony standards are prepared simultaneously with the carrying out of the determination and are subjected to exactly the same treatment as the unknown. (Author's abstract.)

The 262nd meeting was held at the New National Museum as a joint meeting with the Washington Society of Engineers, May 24, 1916. The illustrated lecture of the evening was given by Mr. Joseph Steinmetz, President of tht Aero Club of Pennsylvania, on *The machine shop and the chemical laboratory as related to national preparedness for defense.*

E. C. McKelvy, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 114th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Tuesday, October 3, 1916. Twenty-four members and six guests were present. The program consisted of the following papers:

Dr. C. A. Davis, an appreciation. David White: To be published elsewhere.

R. M. Meade, an appreciation. F. L. Lewton:

Rowland Montgomery Meade, a most promising young botanist connected with the United States Department of Agriculture, died at San Antonio, Texas, June 25, 1916, a few weeks after his twenty-seventh birthday. He was born at Clyde, New York, May 16, 1889, graduated at the high school of his home town, and on the recommendation of Mr. O. F. Cook was appointed, March 15, 1905, as an assistant in experiments with boll-weevil resistant cotton. In 1907, as field agent, he accompanied Mr. Cook to Guatemala, to aid him in his studies of tropical species of cotton and his experiments with cotton insects. On July 1, 1908, after passing a civil service examination, he was appointed a Scientific Assistant in the Bureau of Plant Industry, and he continued his investigations in connection with the cotton plant in Texas, Arizona, and California. In December, 1908, he was elected to membership in the Botanical Society of Washington. On March 1, 1916, he was appointed superintendent of the experimental farm at San Antonio, Texas, under the office of Western Irrigation Agriculture. It was while performing his duties under this assignment that he was stricken with amoebic dysentery and died after an illness of ten days. He leaves a wife and an infant son. All those who came in contact with Roland Meade were attracted by his personal charm and sunny temperament and recognized his mental alertness, which gave promise for a bright future. His interest in growing plants was intense. He looked upon them as real living things,

and delighted to watch their morphological responses to changes of environment. He devised methods of describing and tabulating the minute differences of individual plants, as may be seen in his published papers. The following list of United States Department of Agriculture publications indicates the nature of his studies:

Supernumerary Carpels in Cotton Bolls. Bur. Pl. Ind. Circ. 111.

Methods of Securing Self-Pollination in Cotton. Bur. Pl. Ind. Circ. 121.

A Study of Diversity in Egyptian Cotton (joint author with O. F. Cook and A. McLachlan). Bur. Pl. Ind. Bull. 156.

Arrangement of Parts in the Cotton Plant. Bur. Pl. Ind. Bull. 222.

Single-Stalk Cotton Culture at San Antonio. Dept. Bull. 279.

Roland Meade's many friends in this Society and the Department of Agriculture will always remember him as a clean, lovable young man of great promise, who was cut off at the beginning of his life's work.

Experiments in the use of peat in the greenhouse (with lantern): H. C. Thompson.

Four years experimental work in growing greenhouse crops on muck soils shows that there is a greater difference in the productiveness of the various types than can be accounted for on the basis of fertilizing elements present. Three types of muck soil were used in the experiments. The type showing the smallest percentage of nitrogen and potash produced the largest yields of lettuce, cauliflower, and tomatoes. This was true of the pure muck plats as well as all plats containing muck and clay mixtures (mixtures 75 per cent muck and 25 per cent clay, to 12.5 per cent muck and 87.5 per cent clay). The difference in yields where the various types of mucks were used was probably due to the physical condition and to the organic life in the soil. In a field experiment the muck showing, on analysis, the highest nitrogen content gave the greatest increase in yield when manure was used. This increase from manure could not possibly be accounted for on the basis of plant food, as plats treated with large quantities of complete fertilizers showed a still greater increase when manure was applied. The manure was of special value in inoculating the soil with beneficial organisms. The muck producing the largest yield in the greenhouses showed no increase from the use of manure that could not be accounted for on the basis of plant food. It is interesting to note that the soil producing the largest yield in the greenhouse has been under cultivation much longer than the one producing the smaller yield.

The soil giving the best results produced good yields of lettuce, cauliflower, tomatoes, carnations, and roses. With the first two crops the pure muck plats produced the largest yields, while with tomatoes, carnations, and roses the mixture containing 50 per cent muck and 50 per cent clay produced the largest yields. All mixtures containing 50 per cent or more muck produced greater yields of lettuce, cauliflower, and tomatoes than a mixture containing 3 parts clay, 1 part sand, and

2 parts well rotted manure. In fact, 25 per cent muck practically equalled 33.5 per cent manure.

The speaker concludes that a good type of cultivated muck soil is valuable for greenhouse work and might be used to take the place of a part or all of the manure. However, it is doubtful if it would be practicable to use muck soil for greenhouse work except where it could be secured near at hand at a low cost.

The origin and use of upland peat (with lantern): FREDERICK V. COVILLE.

Upland peat, formed in thickets of laurel (*Kalmia latifolia*), was used experimentally in growing various species of plants. Among those successfully grown were a number of rare species seldom seen in cultivation and very difficult to propagate, including plants belonging to the Ericaceae, or heath family, which cannot be grown with success in ordinary soils. The list includes also several insectivorous plants and orchids.

Perhaps the most interesting and striking of all is an ornamental tree, *Franklinia alatamaha*, discovered in 1765 by Bartram and named in honor of Benjamin Franklin. It has beautiful white, sweet-scented flowers resembling those of a magnolia, but with one of the petals modified to a pouch-like form. This plant, originally from Georgia, is not now known to exist in the wild state. Closely allied to it but with evergreen instead of deciduous leaves is the *Gordonia lasianthus*, of the Southern States, sometimes known as black laurel or loblolly bay. Among our native orchids are the royal lady's slipper, *Cypripedium reginae*, and the pink-flowered *C. acaule*. A fit companion to them is an exquisite climbing lily-like plant sometimes called the empress lily (*Lapageria rosea*) with pendant flowers. This plant, discovered in the forest region of Chile, takes its generic name from that of the family of the Empress Josephine. Among insectivorous plants successfully grown are *Drosera rotundifolia* and other sundews; the curious Venus's flytrap (*Dionaea muscipula*); *Utricularia subulata* and *U. cleistogama* of sandy swamps and pine barrens. Other plants are *Cornus canadensis*, the dwarf dogwood or bunch berry; the fragrant twin-flower (*Linnaea borealis*); *Pinckneya pubens*, with flowers having inconspicuous petals but with a remarkable calyx of which one or two of the lobes are expanded into large conspicuous blades; and *Viola pedata*, the pansy violet of our rocky woods and sterile hills, with palmate leaves and velvety upper petals.

Among the Ericales are *Clethra alnifolia*, the sweet pepper bush of the Atlantic coast; *Dendrium prostratum*, the sand myrtle of the pine barrens; *Azalea vaseyi*, a remarkably beautiful pink-flowered species from the Appalachian region; *A. lutea*, with orange or yellow flowers; the common *A. nudiflora; A. viscosa*, with sweet-scented white flowers; and the cultivated Indian Azalea (*A. indica*). The list also includes *Rhododendron maximum*, the rose bay laurel; *R. carolinianum;* and *R. praecox*, an interesting early-blooming hybrid formed from *R. dahuricam* from the Lake Baikal district of Siberia and *R. ciliatum* of the

Himalayas; *Kalmia latifolia*, the mountain laurel; and *K. angustifolia*, commonly known as lamb kill or sheep laurel; *Leucothöe catesbaei*, with racemes of white flowers; *Eubotrys racemosa*, a coastal swamp plant; *Pieris floribunda*, an evergreen shrub of the Southern States; *P. japonica*, with long pendant racemes of white flowers; *Neopieris nitida; Epigaea repens*, the trailing arbutus or mayflower; *Gaultheria procumbens*, the aromatic wintergreen; and *Pernettya mucronata*, from the Magellan region. Among the heaths are *Calluna vulgaris*, the heather of Scotland; *Daboecia polifolia*, Irish heather; various species of heath from Europe and the Cape of Good Hope; *Gaylussacia dumosa*, the dwarf huckleberry; *G. frondosa*, the dangleberry; *G. ursina*, the bear huckleberry of the southern mountains; *Polycodium stamineum*, the squaw huckleberry or deer berry; *Vaccinium membranaceum; V. parvifolium*, the red fruited whortleberry of the northwest coast; *V. reticulatum*, the "ohelo" of Hawaii; *V. myrsinites*, the evergreen blueberry of Florida; *V. vacillans; V. corymbosum*, the high blueberry; *V. pallidum; V. hirsutum; V. erythrocarpum*, of the Allegheny Mountains; *V. vitis-idaea*, a circumpolar evergreen species; *V. canadense; V. angustifolium; V. nigrum; V. simulatum; V. atrococcum; V. ovatum*, of the Pacific coast; and *V. ciliatum*, the Japanese species. In addition to these species of Vaccinium there are also hybrids between several species. The list also includes *Oxycoccus macrocarpus*, the large American cranberry; *Arbutus unedo*, the Mediterranean madroño or strawberry tree; *A. canariensis*, with large edible fruit, from the Canary Islands; *A. arizonica*, from Arizona; and *A. menziesii* from the Pacific coast of North America.

The Rubiaceae are represented by the partridge berry, *Mitchella repens;* the Empetraceae by the circumpolar crowberry, *Empetrum nigrum;* and the Galacaceae by the well known evergreen *Galax aphylla* of our southern woods.

In addition to these may be mentioned a handsome gentian of the pine barrens, *Gentiana porphyria*, with flowers two inches in diameter; a dwarf fern, *Schizaea pusilla;* several species of Sphagnum, including *S. cymbifolium;* and two exotic plants with exquisitely fragrant flowers, *Daphne odora* from India, and *D. blagayana* from the Balkan region.

W. E. SAFFORD, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 563rd meeting of the Biological Society of Washington was held at the Cosmos Club, Saturday, January 13, 1917; called to order by President HAY at 8 p.m. with 45 persons in attendance.

On recommendation of the council Dr. GEORGE W. FIELD, of the Biological Survey, was elected to membership.

President HAY announced as Committee on Publications: C. W. RICHMOND, J. H. RILEY, NED DEARBORN, W. L. MCATEE; and as Committee on Communications: WILLIAM PALMER, ALEX. WETMORE, R. E. COKER, L. O. HOWARD, A. S. HITCHCOCK.

Under the heading of Brief Notes, W. L. McAtee and Alex. Wetmore called attention to the presence of white-winged crossbills in the vicinity of Washington, constituting the second authentic record of this species in the District fauna. The first specimen was seen by Mr. McAtee on December 10, 1916, in a flock of American crossbills. Later, on December 24, 27, and 30, other specimens were seen, as single birds and also in flocks, Mr. Wetmore having seen as many as forty birds together. In contrast to this unusual visit of a northern bird Mr. McAtee mentioned the lingering of summer birds, having noted a Cape May warbler on December 6, and a bluegray gnatcatcher about January 1. He mentioned also having found a box turtle out and active on January 7, 1917.

Mr. E. A. Goldman mentioned the reported occurrence of Hudsonian chickadees in the vicinity of New York City and Boston.

Mr. A. S. Hitchcock called attention to the unusual precautions that were being taken in the care of the Linnaean Herbarium to protect it from damage by aircraft.

The regular program was as follows:

L. O. Howard: *Some European experiences with entomologists.*

Under this title Dr. Howard read three short papers, entitled "Rennes and René Oberthür," "An Entomological Trip to the Crimea," and "The Episode of Theophile Gautier," all illustrated with lantern slides. In the first he described the personality of René Oberthür, one of the great amateur collectors of insects in Europe, and his beautiful place at Rennes where he has a private museum, an extraordinary arboretum, and one of the largest collections of orchids in existence. He spoke at some length of the very important voluntary assistance which M. Oberthür had given the Bureau of Entomology in the collection and importation of the parasites of the gipsy moth and the brown-tailed moth from Europe into the United States, and gave an account of an automobile journey through Brittany and Normandy in the summer of 1909, on which he was accompanied by M. Oberthür and by Paul Marchal of the Station Entomologique de Paris.

In the second paper he described a journey from Budapest through Lemberg to Kiew in 1907; the establishment of an experimental station at Kiew under the direction of Prof. Waldemar Pospielow of the University of Kiew; the journey thence to Sebastopol, Bachtisserai, and Simferopol, the reginal museum at the latter place under the charge of Prof. Sigismond Mokchetsky; and the excellent work in economic entomology done by Professor Mokchetsky in the Crimea. He mentioned also the old palace of the Khan of the Crimea at Bachtisserai and the marine zoological laboratory at Sebastopol.

In the concluding episode he described his personal experiences in 1910 and 1912 with Theophile Gautier, one of the most successful rose growers of France, at Angers, a man of the simplest appearance and habits and of the highest standing in horticultural circles and an *Officier* of the order of *Mérite Agricole.*

H. C. Oberholser: *Recent additions to the list of North American birds.*

Mr. Oberholser said that the period from 1910 to 1916 inclusive was one of great ornithological activity. During this period fully 125 species and subspecies were added to the list of birds known from North America. Most of these additions resulted from the description of new subspecies or the revival of hitherto unrecognized forms, which together amount to over 100, among the most interesting being five new subspecies from Newfoundland. Two distinct species were described from North America during this time: *Aestrelata cahow* from the Bermuda Islands, and a remarkable new gull, allied to *Larus californicus*, called *Larus thayeri*, from Ellesmere Land. Also a number of extralimital forms were for the first time detected within our boundaries, among the most notable of which might be mentioned *Puffinus carneipes* taken in California; *Totanus totanus* from Greenland; *Calliope calliope camtschatkensis* and *Hypocentor rusticus*, both from Kiska Island, Alaska; *Nyroca ferina*, *Marila fuligula*, *Clangula clangula clangula*, *Cryptoglaux funerea funerea*, *Coccothaustes coccothaustes japonicus*, and *Fringilla montifringilla*, all from the Pribilof Islands; *Poecilonetta bahamensis* from Florida; *Petrochelidon fulva pallida* from Texas; and *Tyrannus melancholicus satrapa* from Maine.

William Palmer: *The fossil seacow of Maryland.*

Mr. Palmer exhibited the fifth thoracic neural arch of a sirenian which was shown to be unlike that of the manatee and to agree absolutely, except in size, with a similar bone of Steller's seacow (Hydrodamalis) from Bering Sea. The specimen was found, freshly fallen, under a cliff of the Calvert Miocene on the western shore of Maryland. It was suggested that the species was living during the period following the first erosion of the Cretaceous and the deposition of the Eocene, as all the specimens so far found in the Miocene were clearly redeposits from an earlier age.

M. W. Lyon, Jr., *Recording Secretary.*

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, February 20: The Anthropological Society, at the U. S. National Museum, new building, Room 44, at 4.30 p.m. Program:

I. M. CASANOWICZ: *The fish in cult, myth, and symbol.*

Tuesday, February 20: The Historical Society, at the Shoreham, 15th and H Streets, N. W., at 8 p.m.

Tuesday, February 20: The Society of Engineers, at Rauscher's, 1034 Connecticut Ave., N. W., at 8 p.m.

Wednesday, February 21: The Medical Society, at the Medical Department of George Washington University, 1325 H Street, N. W., at 8 p.m.

Saturday, February 24: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, February 28: The Geological Society, at the Cosmos Club, at 8 p.m.

Wednesday, February 28: The Medical Society, at the Medical Department of George Washington University, 1325 H Street, N. W., at 8 p.m.

Saturday, March 3: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

A. H. PFUND (by invitation): *The colors of mother-of-pearl.* Illustrated. 25 minutes.

W. F. MEGGERS: *Interference measurements of wave-lengths, and infra-red spectrum photography.* Illustrated. 25 minutes.

F. E. FOWLE: *Spectroscopic field light.* Illustrated. 15 minutes.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editor by the thirteenth and twenty-seventh day of each month.

CONTENTS

Original Papers

Page

Biophysics.—The living plant as a physical system. Lyman J. Briggs.... 89

Proceedings

The Philosophical Society.... 112
The Chemical Society.... 112
The Botanical Society.... 115
The Biological Society.... 118

Vol. VII | March 4, 1917 | No. 5

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII MARCH 4, 1917 No. 5

BOTANY.—*The Mascarene cabbage palm as a new genus.* O. F. Cook, Bureau of Plant Industry.

Soon after landing at Payta, in northern Peru, March 24, 1915, my attention was attracted by a palm growing in the garden of the plaza. Seen from a distance there was a marked similarity in habit and general appearance to the coconut palm, but the proportions were smaller throughout. With a closer view it was soon apparent that the palm did not belong to any American group but to the Old World family Arecaceae, natives of the islands and shores of the Pacific and Indian oceans. Relationship with the genus *Loroma*, described in a former volume of this Journal,[1] became apparent from an examination of the flowers and fruits, and notes were made of the following features:

Trunk rimose, about 6 inches in diameter, thickened at the base to a foot or over, bearing a crown of about 12 leaves, of the general form, texture, and light yellowish-green color of the leaves of the coconut palm, but only about half as long (7–8 feet), with 60–62 pinnae on each side of the rachis. Leaf sheaths grayish, scaly on the back. Lowest pinnae much reduced, the first measuring 8 mm. wide by about 18 cm. long, remaining connected with those above by long marginal ribbons. Second pinnae 9 mm. by 17 cm.; fifth pinnae 1.3 cm. by 28 cm., split at tip; middle pinnae 5.3 by 87 cm., split at the tip a distance of 10–12 cm.; penultimate pinnae 2.8 by 35 cm.; uppermost pinnae about 2.7 cm. by 30 cm., but irregular, consisting of 2–3 small united segments.

Inflorescence attaining a length of 62 cm., the basal joint 4 cm. long, very broad, encircling the trunk. Second joint 1 cm. long, the branches

[1] Journ. Wash. Acad. Sci., 5: 117. 1915.

beginning only 1 cm. or less above the spathe scar. Branches 58, all simple, attaining a length of 45–53 cm., about 5 mm. thick, at base 1 cm. or more, tapering to the apex. Total length of axis 32 cm., 26 cm. above lowest branch.

Buds and flowers light green, the petals somewhat yellowish green, the sepals paler and more whitish. Filaments and pistillode white. Anthers and pollen rather dull, light yellow or buff. Flowers mostly in groups of two, in broad impressions or notches; only staminate flowers on the branch collected. Pistillate flowers with the calyx much larger, and petals imbricate instead of valvate, as shown on the fruits. Pistillode narrowly conic, from a somewhat broader base, slightly lobed at apex, over half as long as the filaments. Mature fruits purplish, with grayish bloom in the wrinkles, pointed-oval, 1.6 cm. long, 9 mm. wide, with a mesocarp of vertical fibers and an endocarp of columnar shell tissue, as in *Loroma* and *Archontophoenix*. Seeds 1.1 cm. long by 7 mm. wide, oval, showing an open network of ruminations, much plainer than in *Archontophoenix*.

Examined afterward at Washington, the seeds seemed to be the same as those representing *Dictyosperma album* (Bory) in the collections. The species is a native of the Mascarene Islands in the Indian Ocean, east of Madagascar, and is rather well known horticulturally.

Nevertheless, the identification appeared unsatisfactory because the generic description of *Dictyosperma* was in some repects distinctly inapplicable, and the availability of the name *Dictyosperma* was brought into question by Mr. S. C. Stuntz. The same name had been used twice before being applied to the palm, first in the form *Dyctisperma*, proposed by Rafinesque in 1838 for a genus of Rubiaceae, and again as *Dictyospermum*, applied by Wight in 1853 to a genus of spiderworts. Its application to a genus of palms, in the form *Dictyosperma*, dates from 1875. Still another version, *Dyctosperma*, perhaps accidental, appeared in a list of palms published by Wendland in 1878.[2]

No detailed description or reference to particular material is given in connection with the original description of *Dictyosperma*, but the distribution, "*Insulae Borboniae et Franciae*," is stated, also the "*Species typica: Areca alba* Bory."[3] But in spite of the

[2] Kerchove de Denterghem, O. Les Palmiers, p. 254. 1878.

[3] Wendland, H., and Drude, O. *Palmae Australasicae*. Linnaea, 39: 181. 1875.

designation of a generic type the application of the name Dictyosperma appears somewhat uncertain. The possibility has to be considered that the genus was not in reality based on the true *Areca alba* Bory, but upon some other palm or palms whose characters had been adopted as those of Bory's species. The original description of the genus includes several characters that do not appear in the palm studied at Payta. In this the flowers are crowded irregularly and are often in pairs or solitary, instead of being arranged in clusters of three, distichous at the base of the branches and in spirals above. The pistillode is conic and tapering instead of long and columnar, and the fruit rather narrowly conic-oval, instead of globose-elliptic.

Thus the problem is not merely to find a name that can be used in place of Dictyosperma, if this be rejected as a homonym, but to have a generic designation that is more definitely applicable to the palm current in the horticultural world as *Areca alba* or *Dictyosperma album*. Under the circumstances it appears inadvisable to propose a new name merely as a substitute for Dictyosperma, since this might carry over to the future the same uncertainty that now attends the application of this generic name. These possibilities of further confusion may be reduced by considering the specimens collected at Payta as type material of a new genus, for which the name Linoma is proposed. The specimens have been labeled *Linoma alba* (Bory), deposited in the U. S. National Herbarium, and catalogued under numbers 866367, 866368, 866369, and 866370.

Linoma Cook, gen. nov.

Trunk solitary, rather robust, distinctly enlarged at base, with rather short internodes and deeply impressed leaf-scars. Leaves large, compound, with very numerous lanceolate pinnae, slender, splitting at the tip, not praemorse.

Spathes two, both complete, thin and membranous in texture, promptly deciduous as soon as released by the fall of the subtending leaf.

Inflorescence with numerous, simple, tapering branches, the flowers crowded irregularly on the axis, inserted singly or in pairs in distinct notches or pits.

Flowers pale green, the staminate with small, triangular sepals, rather thick and fleshy in the middle, prominent or somewhat carinate

on the back; petals oblong-oval, narrowed and somewhat apiculate at the tip, valvate in the bud; stamens 6, the anthers much longer than the filaments in the bud, but exserted at anthesis, when the filaments somewhat exceed the petals. Pistillode tapering gradually from a rather robust conic base, distinctly but minutely tridentate at apex, distinctly exceeded by the mature filaments. Pistillate flowers with sepals and pistils similar, broadly suborbicular, subcordate at base, the petals over twice as long as the sepals, somewhat apiculate at apex, widely overlapping to form a rather deep cup. Staminodes minute, broadly triangular, persistent.

Fruit dull purplish at maturity, nearly symmetrical, rather narrowly conic-oval or subfusiform, tapering abruptly below but much more gradually above, and with an abruptly shouldered apical stigma-scar; pericarp fleshy, greenish, very thin, when dry adherent to the thin mesocarp, and this in turn to the thin, bony endocarp; mesocarp fibers fine, close-set, frequently branched or anastomosing but the branches not diverging; endocarp thin and fragile, but consisting of a distinct layer of bony palisade tissue, as in *Archontophoenix*.

Seed oval, somewhat flattened at the base and slightly apiculate above at the chalaza; raphe scarcely impressed, without distinct fibers, but giving rise at the chalaza and sparingly elsewhere to an open network of impressed fibers following the grooves of the deep radial ruminations. Embryo erect, basal.

As diagnostic characters may be mentioned the simply branched inflorescence, the small number of stamens, the rather narrowly oval fruit and seed, the mesocarp of fine compact fibers, and the bony endocarp. The last feature is shared with *Archontophoenix*, but not the others. The broad coarse mesocarp fibers and adherent endocarp of *Loroma* are very different.

In general habit and aspect *Linoma* is not unlike *Loroma*, which shares the attractive resemblance to the coconut palm. A few days after leaving Payta a fine display of *Loroma* was seen in the Plaza de Armas, at Lima, in front of the Cathedral where tourists go to pay their respects to the bones of Pizarro.

The generic name alludes to the fine, compact texture of the fibrous mesocarp layer of the fruit, a feature which distinguishes at once this genus from *Loroma* and *Archontophoenix*.

The mesocarp fibers are much more numerous, finer, and closer than those of *Loroma*. The individual fibers begin to branch not far above the base, and the divisions often split again near the middle of the seed, and then taper gradually, becoming very delicate before the apex is reached. All of the fibers are very closely united, forming a much thinner and more compact coat than in *Loroma* or *Archontophoenix*.

Two of the fibers lying above the raphe are thicker and more prominent than the others and remain unbranched.

The lack of fibers on the raphe is a rather peculiar feature. A vertical band of a paler color is visible on the inside of the endocarp running from a basal expansion below the embryo to an apical pit at the chalaza. Five or six of the grooves corresponding to the ruminations radiate from the chalaza. The seed when sectioned transversely near the middle also shows grooves, as more or less regular radial divisions around a solid central core. The number of radiating grooves varies from 8 to 11.

The shape of the seed may be considered as a resemblance to *Seaforthia* and *Ptychosperma*, but there are no indications of the broad longitudinal grooves that characterize the seeds of those genera.

The characters of the pistillodes in this group of palms show an unusual form of specialization of these rudimentary organs. The usual tendency in the evolution of unisexual flowers is to reduce the functionless organs, or to suppress them altogether. The staminodes of these palms are mere rudiments of stamens, but the pistillodes show distinct tendencies to share the characters of the filaments, in size, form, and texture. This tendency is least apparent in *Loroma*, is moderately pronounced in *Linoma*, and is best developed in *Seaforthia* and *Archontophoenix*, where the pistillodes even exceed the filaments. Whether the pistillode will be found in any case to be replaced by a normal functional stamen, remains to be seen. Such a change, in which one organ assumes characters that belonged originally to another, is recognized as representing a general class of evolutionary phenomena called translocation or metaphanic variations.[4]

The spathes when fresh are of a thin, fleshy or membranous texture, the inner more delicate, becoming chartaceous when dry and splitting readily into longitudinal shreds. As in *Loroma* the original function of the spathes in protecting the young inflorescences has been assumed by the leaf sheaths. The inflorescence with its spathes remains completely enclosed by the leaf sheath until the flowering stage is reached, being unable to emerge until the leaf falls. Very soon after this the spathes also fall off and the flowers open. The outer and inner spathes of *Linoma* are both complete, and of nearly equal length, but the outer is much broader. The margins are broadly carinate-alate, with the edges very thin and densely pilose, at least near the apex.

[4] Cook, O. F. *Brachysm, a hereditary deformity of cotton and other plants.* Journ. Agr. Research, 4: 397. 1915.

The inner spathes also have a distinct but very narrow carina on each side, running about halfway up. The tip is distinctly apiculate, but not produced. The outer surface is even, but dull, and of a rather light rusty-brown color, while the inner surface appears smooth and shining, but is marked with distinct slightly prominent longitudinal brownish lines, with finer lines and wrinkles between, representing the finer ramifications of the fibro-vascular system.

The number of pinnae and several other features noted at Payta seem not to have been recorded before. Bory and Martius refer to petioles and other parts of leaves as sometimes tinged with red, which may have caused confusion with another palm from Réunion, described by Bory as *Areca rubra*, but now placed in the genus *Acanthophoenix*. It is distinguished readily by the presence of spines on the trunks and leaf-bases. A third species, *Areca crinita*, also described by Bory from the same island, has the trunk and leaf-bases clothed with slender curved spines and hairs. This also is referred by modern botanists to *Acanthophoenix*.

It appears from Bory's account that all three species afford edible "cabbages," but the species now referred to *Acanthophoenix* are said to grow in the mountains, while *Areca alba* is said to prefer the shores and inhabited parts of the island.

It might be presumed that this is the species that is now put up in tins and shipped to Europe and America as a salad delicacy, under the name "hearts of palms" (*coeur de palmier*). A study of a specimen of this commercial product shows the presence of minute slender spines embedded in the loose flocculent coating of the surfaces of the embryonic leaves, which would indicate that the material represents *Acanthophoenix*.

In addition to seeds that have been received on different occasions from commercial horticulturists the Office of Seed and Plant Introduction, Bureau of Plant Industry, has received seeds closely similar to those collected at Payta from Mr. G. Regnard, Port Louis, Mauritius, accompanied by the following note:

A palm that attains a height of 50 feet. Young plants have dark red margins on new leaves which diminishes when the tree becomes older. The true red variety is getting very scarce now as almost all the trees newly planted are a cross mixture with the white. These seeds were gathered on true red sort in a wide plantation of them. The cabbage of this palm is commonly eaten here and has a quite delicate flavor.

These seeds have the Inventory number 38,696. Other importations are numbered 1928, 1929, and 42,365.

ZOOLOGY.—*A revision of the crinoid family Antedonidae, with the diagnoses of nine new genera.*[1] AUSTIN H. CLARK, National Museum.

The family Antedonidae is the most universally distributed of all the families of recent crinoids; its species occur everywhere, ranging from the tropical littoral in both hemispheres uninterruptedly down to the greatest depths at which crinoids have been found, and include all of the strictly antarctic and all of the arctic comatulids.

Owing to the difficulty involved in dealing with the species of this family, which arises chiefly from the altogether extraordinary brittleness and fragility of the great majority, and the resultant lack of some essential feature or other in very many of the published descriptions, no really satisfactory disposition of the included types has as yet been proposed; but it is believed that the following arrangement more nearly represents the true interrelationships of the component species than any of its predecessors.

The species referable to the family Antedonidae fall naturally into forty genera, which in turn are distributed among seven well characterized groups, ranking as subfamilies. These subfamilies with their included genera are the following:

ANTEDONINAE: *Antedon, Compsometra, Mastigometra, Euantedon, Toxometra, Dorometra* (nov.), *Eumetra, Iridometra, Hybometra, Andrometra* (nov.), and *Argyrometra* (nov.).
THYSANOMETRINAE: *Thysanometra* and *Coccometra.*
PEROMETRINAE: *Perometra, Nanometra, Erythrometra,* and *Hypalometra.*
HELIOMETRINAE: *Heliometra, Promachocrinus, Anthometra, Solanometra, Florometra,* and *Cyclometra.*
ZENOMETRINAE: *Balanometra, Psathyrometra, Leptometra, Adelometra, Zenometra, Sarametra* (nov.), and *Eumorphometra.*
ISOMETRINAE: *Isometra.*

[1] Published with the permission of the Secretary of the Smithsonian Institution.

Bathymetrinae: *Orthometra* (nov.), *Tonrometra* (nov.), *Fariometra* (nov.), *Trichometra*, *Hathrometra*, *Nepiometra* (nov.), *Phrixometra* (nov.), *Thaumatometra*, and *Bathymetra*.

Dorometra, gen. nov.

Genotype.—*Antedon nana* Hartlaub, 1890.

Diagnosis.—P_3 is much the longest and stoutest pinnule on the arm; the cirri are XX-XLV (rarely over XL), with not over 16 segments; these have produced distal ends which overlap the proximal ends of those succeeding, and the outer are much longer than their proximal width; the size is small, the arms being from 23 mm. to 50 mm. long; the brachials have smooth, or only very finely spinous, distal edges.

Geographical Range.—Red Sea to Madagascar and Mauritius, eastward to northern Australia and the East Indies, and northward to southern Japan.

Bathymetrical Range.—From the shore line down to 106 meters.

Included Species.—*Dorometra nana* (Hartlaub), *Dorometra mauritiana* (A. H. Clark), *Dorometra gracilis* (A. H. Clark), *Dorometra briseis* (A. H. Clark), *Dorometra parvicirra* (P. H. Carpenter), *Dorometra aegyptica* (A. H. Clark), and *Dorometra clymene* (A. H. Clark).

Andrometra, gen. nov.

Genotype.—*Antedon psyche* A. H. Clark, 1908.

Diagnosis.—P_2 is much longer than P_1, and longer than P_3 though similar to the latter; the centrodorsal is more or less sharply conical.

Geographical Range.—Andaman Islands to southern Japan.

Bathymetrical Range.—From 54 to 201 (?250) meters.

Included Species.—*Andrometra psyche* (A. H. Clark) and *Andrometra indica* (A. H. Clark).

Argyrometra, gen. nov.

Genotype.—*Iridometra crispa* A. H. Clark, 1908.

Diagnosis.—Centrodorsal conical, broader than high, almost completely covered with cirrus sockets which decrease in size toward the apex; these are from LX to LXXX in number; cirri very fragile, with 12–17 more or less elongated segments; P_3 is of the same length and character as the succeeding pinnules; P_1 and P_2, which may be longer or shorter than the following pinnules, have 12–13 segments, and taper evenly to a point; their component segments become progressively elongated; the brachial structure resembles that of *Antedon petasus;* the size is small, the arms being about 30 mm. in length.

Geographical Range.—Hawaiian Islands to northern New Zealand.

Bathymetrical Range.—From 108 to 293 meters.

Included Species.—*Argyrometra crispa* (A. H. Clark) and *Argyrometra mortenseni*, nov.

Argyrometra mortenseni, sp. nov.

Diagnosis.—This species is easily distinguished from *A. crispa* by the much more expanded distal ends of the cirrus segments (in *crispa* the dorsal and ventral profiles of the cirrus segments are everywhere practically parallel), and by the different relationships of the earlier pinnules.

P_1 is 3.3 mm. long, slender and evenly tapering, composed of 12 segments of which the first is slightly broader than long, the second and third are very slightly longer than broad, and the following become progressively elongated, being between four and five times as long as broad distally; the segments are cylindrical and smooth, with little or no development of spines on the distal edges. P_2 is 4 mm. long, very slightly stouter, composed of 12 segments of which the distal are more elongated than those of P_1. P_3 is 5 mm. long with about 12 segments, about as stout basally as P_2 but tapering more slowly and hence appearing stouter, with relatively shorter segments which beyond the third have prominently overlapping and finely spinous distal ends. The following pinnules resemble P_3.

The cirri have 17 segments of which the longest are from four to six times as long as the terminal diameter. The arms are about 30 mm. long.

Locality.—North Cape, New Zealand.

Depth.—Sixty fathoms.

Sarametra, gen. nov.

Genotype.—*Zenometra triserialis* A. H. Clark, 1908.

Diagnosis.—The division series and arm bases are very spiny; the very long rounded conical centrodorsal bears three regular columns of cirrus sockets in each radial area, the radial areas being delimited by broad bare lines; the cirri have 50–60 segments of which the proximal are more or less elongated and the distal are short, never longer than broad, and bear prominent dorsal spines; all of the pinnules are present; the size is large, the arms being about 150 mm. long.

Geographical Range.—Known only from the Hawaiian Islands.

Bathymetrical Range.—Between 346 and 633 meters.

Included Species.—*Sarametra triserialis* (A. H. Clark).

Orthometra, gen. nov.

Genotype.—*Trichometra hibernica* A. H. Clark, 1913.

Diagnosis.—The cirrus segments, which are 25–33 (usually nearer the latter) in number, are cylindrical, without expanded distal ends, and short, the longest (third-fifth) being about one-third again as long as broad, and the distal slightly broader than long; the elements of the IBr series and the lower brachials are without lateral processes, and are widely free laterally.

Geographical Range.—Known only from the western coast of Ireland.
Bathymetrical Range.—From 698 to 900 meters.
Included Species.—*Orthometra hibernica* (A. H. Clark).

Tonrometra, gen. nov.

Genotype.—*Antedon remota* P. H. Carpenter, 1888.

Diagnosis.—The cirrus segments, which are not more than 20 in number, are all short, the longest being not so much as twice as long as the median diameter, and have much swollen distal ends; the IBr series and lower brachials are in close lateral contact.

Geographical Range.—Moluccas to Marion Island, southeast of Africa.

Bathymetrical Range.—From 1089 to 2880 meters.

Included Species.—*Tonrometra brevipes* (A. H. Clark) and *Tonrometra remota* (P. H. Carpenter).

Fariometra, gen. nov.

Genotype.—*Trichometra explicata* A. H. Clark, 1908.

Diagnosis.—The centrodorsal is sharply conical with straight sides, nearly or quite as high as broad at the base; the proximal cirrus segments are elongated, at least twice as long as the median diameter and usually much longer.

Geographical Range.—Philippine Islands to Celébes.

Bathymetrical Range.—From 509 to 1314 meters.

Included Species.—*Fariometra explicata* (A. H. Clark), *Fariometra scutifera* A. H. Clark, and *Fariometra dione* A. H. Clark.

Nepiometra, gen. nov.

Genotype.—*Antedon laevis* P. H. Carpenter, 1888.

Diagnosis.—The centrodorsal is rounded conical or hemispherical, not so high as broad at the base; the proximal cirrus segments are elongated, at least twice as long as the median diameter, and usually much longer; the brachials do not have strongly produced and very spinous distal ends; at most the distal edges of the outer brachials are bordered with fine spines; the cirri have 20–30 relatively short segments of which the last 6–13 are only very slightly, if at all, longer than broad; the pinnules are not especially long, and the distal pinnules are of the same length as the proximal; P_2 resembles P_3 and the following pinnules and is slightly longer and stouter than P_1 with somewhat fewer segments which are proportionately longer; P_2 may bear a gonad, though these usually begin on P_3; the arms are between 25 mm. and 60 mm. in length.

Geographical Range.—Kei and Meangis Islands and southern Celébes; ? Galápagos Islands and Panamá.

Bathymetrical Range.—From 204 to 1158 (?1760) meters.

Included Species.—*Nepiometra obscura* (A. H. Clark), *Nepiometra alcyon* (A. H. Clark), *Nepiometra laevis* (P. H. Carpenter), *Nepiometra io* (A. H. Clark), and *Nepiometra* (?) *parvula* (Hartlaub).

Phrixometra, gen. nov.

Genotype.—Antedon longipinna P. H. Carpenter, 1888.

Diagnosis.—The centrodorsal is rounded conical or hemispherical, not so high as broad at the base; the cirri are about XXX, 20–25; the proximal cirrus segments are elongated, at least twice as long as the median diameter and usually much longer; the brachials do not have strongly produced and very spinous distal ends; at most the distal edges of the outer brachials are bordered with fine spines; the pinnules are very long, the proximal longer than the distal; P_2 is very slightly shorter than P_1, but similar to it, with about 18 elongated segments; the following pinnules are similar; the arms are about 20 mm. long.

Geographical Range.—Southeastern South America.

Bathymetrical Range.—Known only from 1080 meters.

Included Species.—Phrixometra longipinna (P. H. Carpenter).

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOGRAPHY.—*The Navajo country, a geographic and hydrographic reconnaissance of parts of Arizona, New Mexico, and Utah.* HERBERT E. GREGORY. U. S. Geological Survey Water-Supply Paper 380. Pp. 219, with maps, sections, and illustrations. 1916.

The Navajo country includes 25,000 square miles of arid and semiarid lands occupied by about 32,000 Indians and 500 whites. Only a small part of it has previously been described. The report, therefore, includes an unusually full treatment of geography under the heads: historical sketch, geographic provinces, climate, soil, flora, fauna, mineral wealth, population, and industries. Many additions have been made to existing maps, and the list of geographic terms has been revised. Since the future of the country depends upon the solution of the problem of water supply, particular attention was given to the occurrence of surface and ground waters. The Colorado and the San Juan rivers are perennial; all others are intermittent or ephemeral, but their flood waters may be utilized by construction of suitable works. Many springs and seeps may also be developed. The sinking of wells in deposits of various types is recommended, and the parts of the region favorable for artesian flows are indicated. Except for structure sections and maps and the description of water-bearing beds, the report contains little strictly geological material. Such matter will appear in Professional Paper 93, now in preparation. H. E. G.

GEODESY.—*Precise leveling from Reno to Las Vegas, Nev., and from Tonopah Junction, Nev. to Laws, Cal.* H. G. AVERS and G. D. COWIE. U. S. Coast and Geodetic Survey, Special Publication No. 39. Pp. 49. 1916.

This publication gives the results of a line of levels run in 1915 along the railroads between Reno and Las Vegas, Nevada, and between

Tonopah Junction, Nevada, and Laws, California. The line is 547 miles long and fixes the elevations of 228 permanent bench marks. The elevation of the top of rail in front of the railroad stations along the line was also determined. The elevations of the bench marks and of the top of rail in front of the railway stations are given in meters and also in feet. As in all precise leveling in the United States the datum used is mean sea level. The highest point of the line is at Sunland, Nevada, 2171 meters (7122 feet).

The result of a study of the errors of leveling is also given in this publication. The practice of the observer, while setting up the instrument, always to face in the same direction with respect to the line of progress had a tendency to make the line of sight higher for the back sights than for the fore sights. The effect of this has been eliminated by the observer facing in opposite directions at alternate set-ups of the instrument. H. G. A.

GEOLOGY.—*Geology of the Hound Creek district of the Great Falls coal field, Cascade County, Montana.* V. H. Barnett. U. S. Geological Survey Bulletin 641-H. Pp. 215–231, with 1 plate. 1916.

This paper describes the geologic formations, the structure relating to the occurrence or absence of coal-bearing rocks, and the coal resources of the Hound Creek district. The rocks that crop out in the district belong to the Carboniferous, Jurassic, and Cretaceous systems, but detailed study was confined to the coal-bearing Kootenai formation (Lower Cretaceous). R. W. S.

GEOLOGY.—*Contributions to the geology and paleontology of San Juan County, New Mexico. I. Stratigraphy of a part of the Chaco River Valley.* Clyde Max Bauer. U. S. Geological Survey Professional Paper 98-P. Pp. 271–278, with 8 plates. 1916.

This paper is an attempt to set forth the principal features of the stratigraphy in a part of the San Juan Basin, to describe the succession of strata irrespective of possible correlations and thereby to establish a type section for the formations exposed, and to bring out their relations to the strata immediately above and below.

The area studied and mapped comprises about 1500 square miles in northwestern New Mexico extending along Chaco River for about 50 miles from the Great Hogback to Meyers Creek. It includes the outcrops of strata overlying the Mesaverde formation, which have in the

past been referred to the Lewis, Laramie, Puerco, Torrejon, and Wasatch formations.

The stratified rocks of this area consist of a succession of marine, brackish-water, and fresh-water sediments, which now occur as sandstone, slate, coal, and conglomerate, in almost every gradation and combination possible. The strata throughout the greater part of the area dip from 1° to 3° toward the center of the basin. The Mesaverde and Lewis formations and the Pictured Cliffs sandstone are accepted as described by previous workers in the San Juan Basin. The beds above the Pictured Cliffs sandstone that have been classed by others as Laramie are divided into mappable lithologic units and described as the Fruitland formation, Kirtland shale, and Ojo Alamo sandstone. A bibliography is included. R. W. S.

GEOLOGY.—*Some manganese mines in Virginia and Maryland.* D. F. Hewett. U. S. Geological Survey Bulletin 640-C. Pp. 37–71, with 7 figures. 1916.

Six deposits of manganese ore are described with regard to location, geology, and occurrence and origin of the ore. Maps show the surface relations and underground workings of three mines. Replacement deposits of four types are recognized—deposits (1) in residual clay, (2) in the clay of a fault zone, (3) along pervious zones in schistose rocks, and (4) in sediments that fill an ancient channel. Five of the deposits are on the east side of the Great Valley in western Virginia and one is near Lynchburg in the Piedmont region.

The conclusion is tentatively reached that all of these deposits, and probably many more in the belt extending from Maryland to Georgia, were formed while the early Tertiary peneplain was being established in this general region. Four of the deposits outcrop on ridges and spurs that have been so isolated since the peneplain was dissected that they have received little surface drainage since that time, but each of the deposits contains much more manganese than could be derived from the decomposition of a mass of rocks having the volume of the residual clays in which the deposits occur. The clays and manganese minerals have been mined from 200 to 260 feet below the surface and from 170 to 220 feet below water level. In two mines the zone of residual clay and associated manganese minerals extends 105 and 130 feet, respectively, below the level of the nearest streams, which flow in channels cut in bedrock. It therefore appears that the sedimentary rocks of the region may undergo thorough decomposition

to greater depths not only below an extensive erosion surface but also below the present water level than has previously been considered possible. D. F. H.

GEOLOGY.—*Geology of the Upper Stillwater Basin, Stillwater and Carbon Counties, Montana.* W. R. CALVERT. U. S. Geological Survey Bulletin 641-G. Pp. 199–214, with 2 plates. 1916.

The rocks of this area comprise a great thickness of strata ranging from the coal measures of lower Montana (Upper Cretaceous) age to beds more than 8000 feet above the base of the Fort Union formation, of Eocene age. Older sedimentary formations and crystalline rocks are exposed in the Beartooth Mountains, along whose north base there is a profound fault that brings Paleozoic rocks into contact with Tertiary formations south of Red Lodge and with successively older strata to the west.

The Cretaceous and younger rocks, both sedimentary and igneous, are described, together with the geologic structure, which is simple. A discussion of the coal resources is followed by a statement concerning oil prospects. R. W. S.

ENGINEERING.—*Surface water supply of the United States, 1913, Part X, the Great Basin.* NATHAN C. GROVER, et al. U. S. Geological Survey Water-Supply Paper 360, Pp. 293, with 2 plates. 1916.

Surface water supply of the United States, 1914, Part I, North Atlantic slope basins. NATHAN C. GROVER, et al. U. S. Geological Survey Water-Supply Paper 381. Pp. 192 and XXXI, with 2 plates. 1916.

Surface water supply of the United States, 1914, Part II, South Atlantic and eastern Gulf of Mexico basins. NATHAN C. GROVER, et al. U. S. Geological Survey Water-Supply Paper 382. Pp. 66 and XXX, with 2 plates. 1916.

Surface water supply of the United States, 1914, Part VII, Lower Mississippi River basin. NATHAN C. GROVER, et al. U. S. Geological Survey Water-Supply Paper 387. Pp. 60 and XXXIV, with 2 plates. 1916.

Surface water supply of the United States, 1914, Part XII, North Pacific drainage basins, B, *Snake River basin.* NATHAN C. GROVER, et al, U. S. Geological Survey Water-Supply Paper 393. Pp. 248, with 2 plates. 1916.

The water-supply papers listed above are parts of a series giving the results of measurements of flow of streams in the basins indicated in the titles. Numbers 382 and 387 contain appendixes giving lists of stream-gaging stations and publications relating to the water resources of the basins. B. D. W.

ENGINEERING.—*The measurement of silt-laden streams.* R. C. PIERCE. U. S. Geological Survey Water-Supply Paper 400-C. Pp. 39–51, with diagrams. 1916.

San Juan River, in Colorado, New Mexico, and Utah, carries an unusually heavy load of silt, especially during the torrential floods that often occur. The formation of "sand waves" is an interesting phenomenon connected with the heavy silt burden of this stream. Flood measurements are very difficult and sometimes impossible because of the heavy silt load and the accompanying conditions, such as high velocities, trash and drift, shifting channel, and rapid variations in stage. By the use of a stay line and a 60-pound torpedo-shaped weight to hold the current meter in position, with a windlass built into one end of the gage car for handling the meter and weight, it was found possible to obtain measurements during all except the very worst conditions. In spite of the difficulties a good record of the stream flow was obtained. R. C. P.

ENGINEERING.—*Surface waters of Massachusetts.* C. H. PIERCE and H. J. DEAN. U. S. Geological Survey Water-Supply Paper 415. Pp. 433, with 12 plates. 1916.

This volume contains the results of stream-flow investigations in Massachusetts, and a compilation of the available records. The data are arranged on the basis of the climatic year ending September 30, that being the division of the year now generally used by the Geological Survey throughout its work of water-resources investigations. The report contains an introduction by N. C. Grover, briefly sketching the uses and development of the water resources of Massachusetts, which have at all times played an important part in the industrial and commercial development of the Commonwealth. An article on Topography by Arthur Keith outlines the geology of Massachusetts with special reference to the various drainage basins, and gives in non-technical language the geologic history of the river systems. The tables of discharge, showing the flow of the rivers as measured at the gaging stations, are followed by a gazetteer of streams, which lists and describes all the streams, lakes, and ponds shown on the topographic maps of

Massachusetts. A contour map on a scale of 1:250,000, printed in colors, shows the principal drainage basins and the location of gaging stations. C. H. P.

ENGINEERING.—*Accuracy of stream-flow data.* N. C. GROVER and J. C. HOYT. U. S. Geological Survey Water-Supply Paper 400-D. Pp. 53–59. 1916.

Records of stream flow at different gaging stations vary in accuracy with the permanence of the stage-discharge relation, the precision with which the discharge rating curve is defined, the refinement of gage readings, the frequency of gage readings, and the methods of applying the daily gage heights to the rating table to obtain the daily discharge. The contributing factors are so complex that it is generally not practicable to determine mathematically the probable error. A knowledge of the approximate accuracy is needed to apply intelligently the records to different uses; and a knowledge of the sources of error and their relative effects on the accuracy of the records is essential to the proper collection of data for different uses requiring different degrees of accuracy. A study of the accuracy of the records to be collected at any station, therefore, should begin with the reconnaissance for the site and continue through the selection, establishment, maintenance, and operation of the station, the computation and interpretation of the data, and the preparation of the records for publication.

N. C. G.

TECHNOLOGY.—*The resistance of an oil to emulsification.* WINSLOW H. HERSCHEL, Bureau of Standards Technologic Paper No. 86. Pp. 37. 1917.

In this paper is described a new test for the emulsification of oils. Certain results obtained by such measurements are also discussed. The test may be briefly described as follows: 20 cc. of the oil to be tested and twice that volume of distilled water are heated to 55°C. in a 100 cc. cylinder, 26 mm. inside diameter, and stirred for five minutes at a speed of 1500 r.p.m. The cylinder and contents are allowed to stand at the same temperature, and readings are taken at more or less frequent intervals (according to the type of oil) of the volume of oil settled out from the water. From these readings, a maximum rate of settling, called "demulsibility", is easily taken from a table. The paddle is simply a plate of metal 8.9 by 20 by 1.5 mm. Since the test is not sensitive to slight changes of paddle dimensions, they need not be exact, and no calibration is required.

W. H. H.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE CHEMICAL SOCIETY OF WASHINGTON

The 263rd meeting of the society was held at the Cosmos Club, October 12, 1916. The program of the meeting consisted of reports from members of the section upon the various activities at the Fall Meeting of the American Chemical Society at New York City, and on the Second National Exposition of Chemical Industries. W. D. Bigelow, director of the society, reviewed particularly the work of the directors and the reorganization of the management of the *Journal of Industrial and Engineering Chemistry*. J. Johnston, councilor of the section, dealt especially with the majority and minority reports of the Committee on the Proposed Code of Professional Ethics and the work of the Division of Inorganic and Physical Chemistry. Others presenting brief reviews of papers presented at the meetings of the various sections were I. K. Phelps, L. F. Kebler, R. B. Dole, L. C. Wells, J. B. Tuttle, and W. Blum. H. D. Gibbs gave an account of the Exposition and the various symposiums on subjects of present industrial importance.

The 264th meeting, held at the Cosmos Club, November 9, 1916, was devoted to the annual election of officers. The following were elected: *President*, C. S. Hudson, Bureau of Chemistry; *Secretary*, E. C. McKelvy, Bureau of Standards; *Treasurer*, F. P. Dewey, Bureau of the Mint; *Councilors*, R. B. Sosman, Geophysical Laboratory, E. B. Phelps, Hygienic Laboratory, and R. C. Wells, Geological Survey; *Executive Committee*, J. C. Hostetter, Geophysical Laboratory, F. W. Smither, Bureau of Standards. F. C. Cook, Bureau of Chemistry, A. Seidell, Hygienic Laboratory, F. A. Wertz, Bureau of Standards, P. B. Dunbar, Bureau of Chemistry.

The 265th meeting of the society was held as a joint meeting with the Botanical Society of Washington at the Cosmos Club, November 23, 1916.

Dr. Frederick B. Power, of the Bureau of Chemistry, until recently with the Wellcome Burroughs Laboratory, London, gave an address upon the *Aims and developments of phyto-chemical research.* The speaker presented the results and conclusions drawn from a great amount of work carried out in laboratories abroad and largely published in detail in British journals. Particular emphasis was placed upon the enormous opportunity for development in this almost

untouched field of scientific endeavor. Chaulmoogra oil was taken as an example of a phyto-chemical material upon which a great amount of work for the purpose of determining its structure and constitution had been carried out by the speaker and his associates.

The 266th meeting of the society, held at the Cosmos Club, December 14, 1916, was devoted to the presentation of motion pictures showing the manufacture of steel pipe, sheet tin, and tin plate. These pictures were furnished by the courtesy of the American Sheet Tin and Tin Plate Company of Pittsburgh and were presented by D. M. BUCK, Metallurgical Engineer of Pittsburgh.

The 267th meeting of the society, a joint meeting with the Washington Academy of Sciences, was held at the Cosmos Club, January 11, 1917. R. B. SOSMAN, retiring president of the Chemical Society, presented an address on *Some problems of the oxides of iron* (this JOURNAL, **7**: 55–73. 1917).

E. C. MCKELVY, *Secretary.*

THE SOCIETY OF AMERICAN FORESTERS

At the annual meeting of the Society, held at the University Club, January 18, the following officers were elected for the ensuing year: *President*, FILBERT ROTH; *Vice-President*, WILLIAM T. COX; *Secretary*, R. Y. STUART; *Treasurer*, C. R. TILLOTSON; *Executive Council*, W. B. GREELEY, five years, H. S. GRAVES, four years, R. C. BRYANT, three years, D. T. MASON, two years, CLYDE LEAVITT, one year.

R. Y. STUART, *Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 505th regular meeting of the Society was held January 16. At this meeting Mr. WILLIAM H. BABCOCK presented a paper on *Certain pre-Columbian notices of the inhabitants of the Atlantic islands.*

Beginning at the north, the speaker referred to the well known Norse colonization of Iceland in the latter part of the ninth century and to the much earlier establishment of Irish monks at some points of its coast. From numerous Celtic local names Dr. Nansen has argued that there may have been a much greater inland Irish settlement. But perhaps these names should be explained by the fact that there were many Irish and Hebrideans among the early Norse colonists. There are also mentions of "trolls" in the saga of Grettir—and perhaps elsewhere in early Norse writings—as inhabiting hidden places of the mountainous interior. These may possibly preserve the memory of aboriginal survivals from pre-Norse and pre-Irish times, but more probably they merely echo old Norse traditions or are freaks of fancy.

Farther south, perhaps the oldest record is Plato's Atlantis derived from his ancester Solon, who received it, as we are told, from the Egyptian priests of Sais. The speaker related it in slightly condensed form with special heed to anthropologic items, but expressed the opinion that

it merely reflects the civilized life of Plato's time on the Mediterranean shores and throws no light on mankind in the Atlantic. He recited also the description of a far western island, which seems to be Madeira, given in the time of Julius Caesar by Diodorous Siculus, and added the same estimate. He held that this applies also to Plutarch's interesting account of Ogyggia, possibly Ireland or Iceland and the continent beyond it; also to the Irish Sea romances, or Imrama, though the home life which they at times repeated in their tales was very different from the life of the Mediterranean.

In the Geography of the Arab writer Edrisi (about 1154) we seem to find, perhaps for the first time, notes of observations of real human beings on the islands of the eastern Atlantic. A list of these was given with most of the relevant items, showing great diversity in matters of culture, perhaps also of race, but in part agreeing very well with fourteenth and fifteenth century accounts of the Canary Islanders. His sources were partly mythical, partly recent Arabic, and to some extent probably also European, both classic and mediaeval. It is impracticable to identify each island; but some of them are doubtless to be located among the Canaries, one is perhaps Madeira, and two or three at least should be credited to the Azores. We have nothing certain and explicit concerning the latter after this time until the Portuguese colonization, which seems to have found no one in possession, but fortunately there is a considerable body of information as to the Canary Islanders.

The speaker quoted from Major's introduction to the *Canarien* of Bontier and Leverrier, a translation of a letter written at the end of 1341 by certain Florentine merchants dwelling in Seville, Spain, narrating an expedition to the Canary Islands that year, of three Portuguese ships manned partly by Italian seamen. It constitutes one of the best reports ever made of the people of the Canary Islands, who at that time were less affected by European interference than afterward.

Mr. Babcock mentioned a brief settlement of thirteen Spaniards in Grand Canary in 1382, and also the conquest of the islands, begun by Bethencourt in 1402 and completed about 1485. From the same source (Major's introduction) the speaker quoted Azurara's narrative (in the *History of the Conquest of Guinea*, published in 1448) of a slave raid on the island of Palma, participated in by a Portuguese vessel in 1443, the quotation including some account of the inhabitants of the other islands. Further quotations were given from Cadmosto's report on the Canary Islands in 1455, about the middle of the conquest, some of the islands being then still unconquered and pagan. The speaker then gave, from the body of the *Canarien*, several selections presenting similar anthropological matter. A few words as to matters of race and culture closed the paper.

The presentation of the paper was followed by a general discussion of the subject in which the speakers were Dr. Aleš Hrdlička, Dr. John R. Swanton and Dr. Truman Michelson.

Frances Densmore, *Secretary*.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, March 6: The Anthropological Society, at the Public Library, at 8 p.m.

Tuesday, March 6: The Society of Engineers, at Rauscher's, 1034 Connecticut Ave. N.W., at 8 p.m. WILLIAM A. MITCHELL, Major in Corps of Engineers, U. S. Army, will give a lecture on Aeronautics, illustrated by lantern slides.

Saturday, March 10: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, March 14: The Geological Society, at the Cosmos Club, at 8 p.m. Program:

HARRY FIELDING REID: *Distribution of land and water on the earth.*

WILLIAM BOWIE: *Some results of recent gravity observations by the Coast and Geodetic Survey.*

DAVID WHITE: *Discussion of gravity anomalies from the stratigraphic standpoint.*

Wednesday, March 14: The Botanical Society, at the Ebbitt House. The annual dinner, followed by the address of the retiring President, A. S. HITCHCOCK.

Saturday, March 17: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

W. BOWIE: *Our present knowledge of isostasy* (illustrated). 30 minutes.

W. F. G. SWANN: *The origin and maintenance of the earth's electric charge* (illustrated). 30 minutes.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editor by the thirteenth and twenty-seventh day of each month.

CONTENTS

Original Papers

Page

Botany.—The Mascarene cabbage palm as a new genus. O. F. Cook ... 121

Zoology.—A revision of the crinoid family Antedonidae, with the diagnoses of nine new genera. Austin H. Clark ... 127

Abstracts

Geography ... 132

Geodesy ... 132

Geology ... 133

Engineering ... 135

Technology ... 137

Proceedings

The Chemical Society of Washington ... 138

The Society of American Foresters ... 139

The Anthropological Society of Washington ... 139

VOL. VII

No. 6

MARCH 19, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII MARCH 19, 1917 No. 6

ELECTROCHEMISTRY.—*The electrometric titration of zinc with ferrocyanide.* F. RUSSELL V. BICHOWSKY, Geophysical Laboratory. (Communicated by Arthur L. Day.)

The purpose of this note is to point out a set of very interesting polarization phenomena that occur at a platinum electrode when certain insoluble salts, such as zinc, ferric copper, lead, or manganous ferrocyanide, are being precipitated. Only the case of zinc ferrocyanide will be discussed here.

If we place a platinum electrode in a solution of potassium ferrocyanide and titrate this solution with a solution of some zinc salt the e.m.f. of the electrode measured against some standard electrode, such as the normal calomel electrode, follows a perfectly normal curve beginning at about -0.08 volt (the e.m.f. of the ferrocyanide electrode) and increasing slowly with the addition of the zinc solution until near the end point; on the addition of a drop in excess of the amount of zinc solution necessary to precipitate all the ferrocyanide the e.m.f. increases very sharply to -0.40 volts. With further excess the e.m.f. stays approximately constant, reaching a maximum value of about -0.45 volts. The electrometric end point is thus very sharp, and the platinum electrode is by all means the most accurate and convenient device for determining the end point of the zinc ferrocyanide titration.

However, if instead of adding zinc solution to a ferrocyanide solution we reverse the process and add ferrocyanide to the

zinc solution, the initial e.m.f. of the platinum electrode, instead of having the invariant value of − 0.45 volts can be made to have almost any value between 0.0 and − 0.5 volts, depending on the previous treatment of the electrode. If the electrode has been allowed to stand in contact with a ferrocyanide solution for some time the e.m.f. will be between − 0.1 and − 0.25 volts, depending on the length of time it has been in the solution; if it is charged to say − 2.0 volts while in contact with a zinc solution the initial e.m.f. of the electrode may reach the reversible value of − 0.45 volts, or even higher.

If the electrode has been adjusted to an e.m.f. of − 0.45 volts and the titration of zinc with ferrocyanide carried through as before, the exact reverse of the previous curve is obtained, the e.m.f. begins at − 0.45 volts, drops sharply at the end point to − 0.10 and continues at nearly that value on further addition of ferrocyanide. In this case, therefore, our initial curve is reversible. If, however, the platinum electrode has been treated so that it shows an initial voltage of say − 0.20 volts, on adding the ferrocyanide solution the numerical value of the e.m.f. increases slowly, instead of decreasing, this increase continuing until the curve that is obtained by plotting e.m.f. against cc. of ferrocyanide added intercepts the normal curve. At this point the e.m.f. is a maximum. From this point on the e.m.f. curve is entirely normal, the end point being perfectly sharp and unchanged. This phenomenon is similar to the one noted by Forbes and Bartlett[1] for the titration of ferrous iron with dichromate, but in our case not only is it possible to avoid the phenomenon entirely by the proper treatment of the electrode already indicated, but it is also possible not only to control the initial e.m.f. of the electrode, but also the shape and slope of the ascending (abnormal) part of the curve, thus causing the point of interception of the abnormal and normal curve to be varied. In a well stirred solution the abnormal curve starting at − 0.2 volts will almost always intercept the normal curve just before the end point is reached, however, if the stirring is made very

[1] Journ. Amer. Chem. Soc., **35**: 1527. 1913.

poor so that there is any large excess of ferrocyanide in contact with the electrode before the zinc is all precipitated, the end point can be suppressed entirely; or, if by various devices the titration is carried on so that the electrode is always in contact with small concentrations of both zinc and ferrocyanide ion, the point of interception of the normal and abnormal curve can be moved almost to the beginning of the titration, the titration curve thus having a very flat rather than the usual sharp maximum. Of course, in all these cases, except in the case of no stirring, the end point is perfectly sharp and reproducible, and under any of these varied conditions this method of determining the end point is much more rapid, convenient, and accurate than those employing the usual indicators (iron or uranium).

All these phenomena seem to show that in cases of this type depolarization can be accomplished only by some agent (in this case ferrocyanide, in Forbes and Bartlett's case, ferrous iron) whose oxidation and reduction reactions on the platinum electrode are reversible, and that the persistent irreversibility of the Forbes and Bartlett curve and of our curve was due simply to the fact that the only substance in the solution capable of rapid reversible reaction at the electrode was removed from the possibility of acting—by precipitation in our case, and by the excess of an irreversible strong oxidizing agent in Forbes and Bartlett's case. This explanation is independent of any theory of the cause of polarization

MINERALOGY.—*Neodymium as the cause of the red-violet color in certain minerals.*[1] EDGAR T. WHERRY, U. S. National Museum.

Impressed by the intense red-violet color shown by the permanganates, many chemists are inclined to interpret the similar colors occasionally shown by normally colorless minerals, such as calcite and apatite, as due to the presence of manganese. Of course, permanganates may be at once excluded from consideration, for they can only be produced by a somewhat vio-

[1] Published by the permission of the Secretary of the Smithsonian Institution.

lent process—fusing with alkalies and then acidifying—in the course of which the minerals would be destroyed; moreover they are extremely unstable, and even if formed could hardly persist long. Finally, permanganates show a highly characteristic absorption spectrum—observable by placing their solutions between a source of white light and the slit of a spectroscope—consisting of six bands in the yellowish green, green, and greenish blue; but not a trace of this absorption spectrum is shown by any mineral thus far studied.

Certain manganic compounds, containing trivalent manganese, are, however, also red-violet in color, and may develop in minerals under mildly oxidizing conditions. Even colorless bottle-glass, on lying out in the sunlight for a time, becomes red-violet owing to the oxidation of the manganese to that valency.[2] Such manganic compounds show a single rather hazy absorption band in the greenish blue, but only indistinct general absorption of the colors complementary to red-violet.

On the other hand, there is at least one other chemical element, the rare-earth metal neodymium, which has red-violet or violet-red colored compounds; and these yield a highly characteristic absorption spectrum, consisting of an intense band in the orange-yellow, a fainter one in the green, and, if sufficiently concentrated, additional ones in other parts of the spectrum. These bands can readily be seen if a solution of monazite in sulfuric acid is placed between the source of light and the spectroscope slit. They can also be observed in a number of minerals, by the use of the microspectroscope.[3] Of course if the mineral occurs in large enough masses, the ordinary spectroscope may be used, and the mineral be simply placed between the source of light and the slit; those described in this note give good results by this method.

It was pointed out by Headden some years ago[4] that the

[2] See Gortner, R. A. Journn. Amer. Chem. Soc., **39**: 157–162, 1908.

[3] See the writer's paper, *The microspectroscope in mineralogy*, Smithsonian Misc. Coll., **65**, No. 5, 1915.

[4] Am. J. Sci., [4] **21**: 301, 1906.

red-violet[5] calcite from Joplin, Missouri, gives this neodymium absorption spectrum. This was confirmed by the writer in the paper referred to, and in addition it was noted that the red-violet calcite from Rossie, New York, shows, faintly, the same spectrum. Specimens from Sterlingbush, New York, recently received by the National Museum in exchange from the New York State Museum, have the same color as the latter occurrence, and show the same absorption spectrum.

That manganese is not the cause of the color of these calcites is shown by the following considerations: The calcites contain ferrous iron, and must accordingly have been formed under reducing rather than oxidizing conditions, so that any manganese present must be in the manganous state. Now manganous carbonate, the mineral rhodochrosite, is pure red in color, and that this color is not essentially changed by association of the manganese with calcium is evident from the pale red color of the so-called manganocalcite, such as occurs for instance at Franklin Furnace, New Jersey. Furthermore, many calcites known to contain moderate amounts of manganese show no color whatever. The minute trace of manganese present in these red-violet calcites could therefore not by any possibility produce their color.

There is thus both positive evidence (the absorption spectrum) and negative evidence (the inability of manganese to produce the color) in favor of the view that red-violet calcite in general owes its color to neodymium.

The mineral apatite is sometimes violet in color, but, as recorded in the writer's paper above cited, usually shows no absorption spectrum. Oddly enough the well known brown apatite from Ontario, Canada, yields the absorption bands of neodymium, although any red-violet color that this metal produces is masked; most of the crystals show an underlying green color, due presumably to ferrous iron, the brown being only a sort of local mottling which could readily be produced by irregular distribution of a pale red-violet coloring matter.

[5] An effort was made to name the colors of these calcites according to Ridgway's "Color standards and nomenclature," but accurate comparisons of colors seen only in thick layers of a transparent mineral and those painted on sheets of paper are impracticable. The approximate position of the calcite colors is, however, 67, violet-red, composed of red 52 per cent, violet, 48 per cent.

It would naturally be expected that an occurrence of neodymium-bearing apatite free from the green color of ferrous iron would actually show the red-violet; which expectation has now been fulfilled. The U. S. Geological Survey has recently transmitted to the National Museum an extensive series of minerals collected by Dr. W. T. Schaller in the pegmatites of southern California, among which are two kinds of violet apatite. One, the color of which is pure violet, from the Mountain Lily Mine, Oak Grove, agrees with apatites from Maine and Saxony, previously examined, in color and in absence of absorption spectrum; no guess will here be hazarded as to the cause of its color. But the other, from the San Diego Mine, Mesa Grande, has a red-violet color similar to that of the Joplin calcite, and shows an even more intense absorption spectrum, so is to be regarded as also owing its color to neodymium.

GENETICS.—*A correlation between endosperm color and albinism in maize.* J. H. KEMPTON, Bureau of Plant Industry. (Communicated by G. N. Collins.)

Seedlings in which chlorophyll does not develop occur not infrequently in many cultivated species. Such plants are known as albinos. As photosynthesis is impossible without chlorophyll these seedlings soon perish. Some varieties of maize produce many albino seedlings, and it has been possible to isolate strains which give regularly a certain proportion of albino seedlings. Several investigators have tested the exactness of the ratio between normal and albino plants and have concluded that albinism is a simple Mendelian character, recessive to the normal form.[1]

[1] EAST, E. M., and HAYS, H. K. *Inheritance in maize.* Conn. Agr. Exp. Sta. Bull., clxvii, 1911.

EMERSON, R. A. *The inheritance of certain forms of chlorophyll reduction in corn leaves.* Nebr. Agr. Exp. Sta. Twenty-fifth annual report. 1912.

GERNERT, W. B. *The analysis of characters in corn and their behaviour in transmission.* Published by author, 1912.

MILES, FRANK C. *A genetic and cytological study of certain types of albinism in maize.* Journal of Genetics, 4: 193. 1915.

In studying the effects of temperature and light upon the rate of elongation of albino seedlings the writer had occasion to grow seedlings from an ear which had both yellow and white seeds, and found what appears to be a correlation between the color of the endosperm in the seed and the development of chlorophyll in the seedlings. The ear from which this seed was secured was the result of a self-fertilized first generation plant of a cross between *Zea tunicata* and *Zea ramosa.* This cross has been recently described in detail by Mr. Collins.[2]

The ear was non-podded and had approximately three yellow seeds to one white. The actual figures were 70 yellow and 18 white. These yellow seeds were similar to those reported by other investigators of yellow endosperm in that they varied greatly in the intensity of the color, but in this instance little difficulty was encountered in segregating the white seeds. The 70 yellow seeds were divided into four groups with respect to the intensity of the color, the two darkest groups having 18 seeds each, and the two lightest groups having 17 seeds each.

TABLE 1

	NORMAL	ALBINO
Dark yellow	17	1
Yellow, grade 1	16	2
Yellow, grade 2	13	4
Yellow, grade 3	11	6
White	6	12
Total	63	25

Fortunately every seed germinated and it was immediately seen that there was a correlation between white or colorless endosperm and albino seedlings. The percentage of albino seedlings from the yellow seeds is 18.6, while the white seeds produced 61.5 per cent albinos. Had we been growing only the white seeds from this ear a very misleading conception of the ratio of albino to normal plants would have resulted. It is also

[2] COLLINS, G. N. *Hybrids of Zea ramosa and Zea tunicata.* Read at the meeting of American Naturalists, New York, December 29, 1916.

obvious that in a population of yellow and white seeds having an association between white endosperm and albinism the percentage of homozygous yellow plants would be greatly increased owing to the differential death rate between the yellow and white.

The five classes of seeds planted with the resulting seedling classes are shown in Table 1.

Arranged in the form of a fourfold table by combining the four grades of yellow the classes are as shown in Table 2.

TABLE 2

	NORMAL	ALBINO	TOTAL
Yellow	57	13	70
White	6	12	18
Total	63	25	88

The coefficient of association by Yule's method[3] is 0.795 ± 0.072 which is certainly too large to be ascribed to chance.

Using Pearson's formula[4] for the mean square contingency, $C_2 = 0.395 \pm 0.057$, which is a deviation above a zero correlation of 6.9 times the error. Although the number of individuals is small, the fact that the proportion of albino seedlings increased as the intensity of the endosperm color diminished may be of some significance. If it is assumed that the differences in shade between the four classes of yellow endosperm are due to separate factors, it would seem that these several factors are correlated with albinism, which on the linkage hypothesis would necessitate that these associated factors be located on the same chromosome.

As with many simple characters there are several degrees of albinism which grade from white to yellow by imperceptible stages. The present albino seedlings, while they were easily separated from the normal plants, varied among themselves from almost pure white to an appreciable amount of yellow.

[3] YULE, G. UDNY. *On the methods of measuring association between two attributes.* Journal Royal Statistical Society, 75, Part VI, May, 1912.

[4] PEARSON and HERON. Biometrika, 9: 167. 1913.

As the total number of albino seedlings was small no attempt was made to classify the degrees of albinism in relation to the degrees of endosperm color.

The inheritance of endosperm color has been studied by several investigators who have concluded that this character is composed of at least two factors. The results are not easily interpreted even with two factors, the investigations revealing many complications, and it is possible that these may be due at least in part to a linkage between the several factors for endosperm color.

The present correlation may be considered in the nature of a coherence since it is highly probable that the albino character and white endosperm were brought into this cross from the tunicate parent. The progeny of a self-pollinated ear from a sister plant of the male parent of the cross between *Zea ramosa* and *Zea tunicata* was noted in 1916 as having produced many albino plants. The yellow endosperm undoubtedly came from the ramosa parent and thus far no albino seedlings have been found in the strain of *Zea ramosa* we have been growing.

There is, however, the possibility that this apparent coherence is in reality a physiological correlation between white or albino endosperm and albino seedlings. As a demonstration of the truth or fallacy of this statement a strain having yellow endosperm, and producing gametes carrying the albino character should be crossed with a white strain lacking the albinistic tendency, but the final results of such a cross cannot be obtained before the fall of 1918.

ETHNOLOGY.—*An initiation at Hano in Hopiland, Arizona.*
J. Walter Fewkes, Bureau of American Ethnology.

There are three pueblos on the East Mesa of the Hopi Indians called Walpi, Sitcomovi, and Hano. These villages, situated in Northeastern Arizona, are composite in population and have been affected in different degrees by influx of clans from different directions the former homes of these clans now indicated by ruins. The inhabitants of Walpi are homogeneous. Sitcomovi, originally settled by clans from Zuñi, has lost the Zuñi

idiom, but still retains a ritual which is essentially Cibolan (Zuñian). The latter pueblo is regarded by the Zuñi as one of their pueblos among the Hopi, its architectural features being those characteristic of Tewa pueblos on the Rio Grande. Architecturally Hano is also Tewan, and its inhabitants retain the Tewa idiom, its mythology and ritual being distinctly Tanoan, little modified by the neighboring Walpi.

The general character of the rituals in these three villages is known, but very little has been published on the ritual of the relatives of the Hano people who now live along the Rio Grande, especially as to the nature of the initiations of youths into societies of priests. The Hopi introduce personifications of ancestors in their pagan dances, and call the personators by the name, Katcinas (Cachenas), but apart from that our knowledge is fragmentary. At Hano this worship formerly survived in its original form, so that the following pages may give an idea of the initiation of boys and girls into the Katcina cult as once practised, possibly still persisting, in villages along the Rio Grande.

The month of February is an active one ceremonially in the calendar of the Hopi towns. It is the month when lustration rites are performed to purify the earth from the malign influences of a power which through sorcery is supposed to rule it in winter. In that month, the return of the Katcinas, led by their father, the Sun or Sky-god, is personated. The clans that came to the Hopi from the south personate the return of their Sky-god in December, the clans of Sitcomovi in January, but the Katcinas are supposed to return in February and to remain about the villages until July, when their departure is celebrated in an extended farewell festival. The February ceremony is called, in secular language, the Bean Planting, because beans are sprouted in the kivas to be symbolically used by the returning Sun-god to represent the fructifying forces of nature. These sprouted beans are given at that time to the heads of all the clans by the personator of the Sky-god, in answer to their prayers, as a symbolic promise of good crops during the year.

Of the various steps in initiatory rites from birth to maturity, in the life of pueblo children, none is regarded more important

than the last, or that in which they are taught the mysteries of the Katcinas. A child under thirteen or fourteen years of age is not supposed to understand the nature of these supernatural beings, but to believe that from time to time family ancestors or spirits of the dead revisit the pueblos and receive prayers for the good of the tribe, after which they return to ghostly homes in the underworld, through the house of the sun far to the west. At this age they are among other things made acquainted with the fact that the Katcinas are not real supernatural beings, but personations by their own parents. But they must obtain this knowledge through initiation, some of the ordeals of which may be regarded as severe and are certainly calculated to bring out the moral courage of the novitiates. Many rites occur, one of which is a ceremonial flogging of children, which takes place in the presence of chiefs and other persons of the tribe. The rite at Hano, the subject of this article, has never been described.

To understand the meaning of this event and the place the Katcina cult occupies in the pueblo mind, it may be well to say a word on this subject before we pass to the consideration of the initiatory episode. In all their cults Hopi ceremonies show many indications of the worship of divinized ancestors, but this is especially true in those of the Katcina worship. The spirit dead are supposed to become Katcinas. The breath bodies of men pass to their future home, the underworld, a realm of the departed, presided over by the supernatural being called the God of Germs. The population of this underworld includes not only the spirits of those long ago deceased, but also those who have lately joined them. This ghostly population is supposed to have a social organization like that inhabiting the upper world, being as on earth divided into clans with related priesthoods, in all the conditions of life duplicating what is found among the living. There are male and female Katcinas, brothers, sisters, uncles, aunts, and various other relatives on the mother's side. The clans of the underworld, after death, bear names of the living, and are symbolically characterized. We have for instance, the Bear clan, the Badger clan, and others. Prominent among all members of each underworld clan are the oldest members,

the ancestral parents of each clan, elevated to the cultus hero and heroine of the clan. The sun of course is father, and the earth, mother; they are common parents of all clans.

With this idea of the clan arrangement of the dead in the underworld let us consider their relation to the living clans, for this is the foundation of this cultus. Clan relationship not being severed by death, the deceased members are regarded as still members of the clan, with the same obligation to the clan as when alive on earth. What is most important of all is that the powers of these spirit ancestors are regarded as most efficacious in answering the prayers of the living. In other words, the clansmen of earth of the Bear clan feel that by addressing prayers to their relatives in the underworld, they, with their aid, can bring about what they desire. This can be accomplished by the use of magic or other supernatural agencies. The personation of ancient members of the clans are "conjured up" to hear the petitions of those of their clan, still living.[1]

The February ceremonial has for its primary purpose a celebration of the advent of these ancestral personages, while that in July celebrates their return to their homes in the underworld. The flogging of the young initiates, like other ritualistic episodes, contain many archaic survivals that have a foundation in an early myth recounting how the cult hero was initiated by the Sun father, in like manner.

The flogging ceremony at Hano, here described, took place in the larger of the two kivas, or sacred rooms, just before sunset on the 14th of February, 1900. This rite has been witnessed more than once, but the variations are slight, at most, and have no great significance.

As with all pueblo ceremonies some time is occupied with preparation of the paraphernalia used, as it has to be renovated for the special purpose. The walls of the room were replastered, and its floor thoroughly swept; all secular objects, as blankets in progress of weaving, were rolled up and put away, and smaller

[1] These returning clan members are represented by living members, who, for the time being, believe that they really become the members of the spirit branch of the clan which they represent.

objects tucked in certain niches made in the wall for that purpose. Boxes containing soil, in which bean seeds[2] had been planted a week before, were concealed by a wagon sheet hung across the end of the room.

Three personators took the prominent parts in the child flogging, two of whom personated the great Sky-god and the third represented the earth, or old woman, who they believe makes the germs of life grow. The personator who flogs the children represents the father of all living on earth as well as inhabitants of the underworld.[3] An account of his costume may be instructive as embodying their symbolic conception of these supernaturals.

Each personator of the Sky-god wears on his head a mask-helmet, painted black, and adorned with clusters of feathers, long beards made of horsehair with attached feathers hanging from their chins. The body, upper arms, and thighs are painted, smut from the bottom of an old cooking pot serving for black paint. Markings are drawn with gypsum on the upper arms and thighs, and the legs and forearms are painted with the same material. Several ears of corn strung together form their belts from which, reaching to their knees, hangs a fringe of horsehair stained red, the body being naked. This crude representation of the Sky-god has the same symbolic marks as a wooden idol of this god on a Hopi altar, and is called Tuñwup Katcina.

The three personators dressed near a shrine outside the kiva on the trail below the pueblo and entered Hano from the east in order to preserve the illusion that they came from a distant place in the east, where the sun, whom they personify, rises. They entered the kiva where spectators had already assembled, and shortly after their appearance, the man personating the Earth-woman entered the room passing through the hatchway

[2] These beans were forced to sprout in midwinter in a superheated atmosphere of the kiva, and were carried later by the Sun-god to represent symbolically fructification of food plants. Children were formerly taught that these sprouting beans are brought by a supernatural being, not being permitted to know that they were raised by their parents in the kiva.

[3] These men belonged to Hano clans. There are two Sky-gods in their mythology, one representing the sun, and the other the moon.

down the ladder bearing a flat basket with sacred meal to be used in the ceremonies.

It was about four o'clock, in the afternoon, when Anote, the village chief of the pueblo, Hano, entered the kiva, bearing in one hand two wands made of the leaves of the yucca or century plant, in the other hand his medicine bowl and a badge, indicating his standing as a chief. He placed this badge on the floor and deposited his medicine bowl near it. He then poured into the latter a white liquid, making passes in sequence with his hand towards the six cardinal points: north, west, south, east, above and below. He then stripped off the spines from the margins and points of the yucca leaves, scooped some of the medicine from the bowl into one hand and drew the leaves through it. Aided by another man he tied several leaves together making two whips, which were laid on the placque containing the prayer meal brought by the old woman.

By this time spectators had begun to assemble in the room, each one taking his seat on the raised floor at one end of the room. When they were seated, a number of adults, men and women, each accompanied by a child, who carried an ear of corn called "mother" in one hand, filed into the kiva and seated themselves along the sides of the room. When all were gathered the chief began to construct a rude altar on the floor of the room. He first made a low ridge of sand a few inches high into which he planted, upright, a row of 20 wing feathers. In front of these feathers he outlined on the floor, with meal, three semicircular figures, side by side, representing rainclouds, and added parallel lines of meal symbolic of falling rain. On the middle raincloud figure he set upright the badge of his office. A few feet in front of these figures near the firehole, he outlined with a line of meal a square figure crossed by two diagonals, on the junction of which, in the middle, he laid two small feathers. Having completed these preliminaries the chief took his seat back of the line of feathers and gave the signal that he was ready for the rite to begin. Shortly after, steps were heard on the kiva roof above followed by a voice hooting down the opening or hatchway, demanding permission to enter. The chief mounted the ladder

and spoke to those above. Immediately there followed him down the ladder the two personators of the Sky-god, and a man dressed as an old woman. These three made a circuit around the fire hole six times, after which the earth woman personator holding the basket of meal and whips, took position near the bottom of the ladder, and the two Sky-gods stood, one on each side of the rectangular meal figure on the kiva floor. The latter then began a rapid dance bending and swaying their bodies and shouting to the assembled spectators. Each was then handed one of the yucca whips, previously prepared as mentioned above, after which they resumed their dancing, calling out loudly for the children to come and be flogged. In a short time a woman led forward a girl about 11 years old, whose garment had been removed from her back, and placed her within the square outlined with meal. One of the Sky-gods immediately struck the bared back with the yucca wand several times, all the while continuing to dance and shout. He than passed to the other side exchanging places with his companion and the foster mother bared her back and was flogged as her child had been before her. The two Sky-gods again exchanged places, and whips, as yet unused, were given to them, after which a man, possibly a father, led a boy forward, both stepping inside the rectangle of meal. The boy was first flogged on the back in the same manner as the little girl, and the father was struck several times also on legs and arms. As each person entered the space occupied by the meal figure he took a pinch of meal and, raising it to his lips, threw it toward the Sky-god, uttering an inaudible prayer. The flogging continued until four children, and as many foster parents, or the men and women accompanying the children, had been treated in this way. Generally the punishment was received by the children without a flinch, but one of the girls was frightened. The Sky-god was lenient, simply whirling his whip over her head, without striking.

At the close of the flogging of initiates, other children, mostly boys, not initiates, voluntarily came forward and stood with backs bared for the whips. They were struck, oftentimes rather severely. Then adults, one after another, including the old

chiefs, stood up and were flogged, in the same way. As each person passed to the altar after receiving the blows he took a little liquid from the medicine bowl or meal from the basket, rubbed it on his wounds, without a word, and took his seat on the floor. The personators then left the room, after which the chief spoke at length, in Tewa idiom, to the assembled people. The author did not understand Tewa, but was told by an interpreter that he spoke to them on the meaning of the rite. He may have explained that it was a dramatization of an old legend and that the floggers were their own relatives personating supernatural beings. Following the speech the spectators then crowded around the altar, dipped their hands in the medicine, and took a handful of meal with which they rubbed their bodies, as both liquid and meal are considered salutary. At the close of the ceremony the children were led out of the room by their parents to their own homes.

On February 15, the day subsequent to that in which the flogging above described was performed, there was celebrated at Walpi one of the most unusual of all rites of the Bean-planting festival. The main events of this ceremony were prayers to a supernatural being called Masauu, the god of planting, also known as the supernatural of the "surface of the earth." The dramatic reception of Masauu occurred in a Walpi kiva at 8 o'clock in the evening and lasted far into the night. It is such an unusual event, having been witnessed by the author but once, that although it has no direct connection with the child-flogging it is introduced here, for want of a more appropriate place.

On the night when Masauu's visit was personated all fires throughout the East Mesa were extinguished. No one was met in the streets. Women and children were in hiding in back rooms, and darkened house terraces were deserted, for the dread being is greatly feared by all the Hopi. Knowing that he was to be personated that night, the author resorted to the chief kiva, in Walpi, early in the evening, and found about 20 men engaged in decorating their bodies with white kaoline paint, drawing lines down their backs and legs and placing

great daubs of white on their cheeks and hair. None of these men were masked, but all claimed they personated sisters or brothers of Masauu. Shortly after the author's entrance they began to sing their songs, containing strains of fine archaic Hopi Indian music, closely resembling in their cadences the song sung by the antelope priests in the well-known snake dance. While these songs were being sung a priest came down the kiva hatchway bearing two large hollow gourds, the surfaces of which had been painted black, and spattered with a wash containing glistening hematite. Each gourd was large enough to fit over the head and both were later worn as helmets by personators of Masauu. With these gourds the same priest brought two planting sticks of ancient form and two flat basket plaques which were laid with great reverence alongside the masks, near the fire hole. At the advent of this man all those present ceased their singing and lighted their pipes for a formal smoke, during which the pipes were passed around, every man silently puffing clouds of smoke upon the masks. No one of that gathering spoke a word but each fervently prayed in sequence, beginning with the chief, at the conclusion of which they again returned to their usual songs. During these songs one of the chiefs raised the painted gourd helmet and talked directly to it praying for success of crops during the coming season. The songs rose and became so loud that no one could tell what was said, but the intent throughout were prayers to fertilize the fields that the corn might germinate and grow. Shortly after, while the men were still singing and the light of the fire had been shielded from all eyes by a blanket, in order to darken the room, a naked man silently and unannounced came down the ladder, not as is usually the case backwards holding on the rungs, but as one would descend a pair of stairs. Entering the room without making the customary request, "Am I welcome here?" he slipped around back of the row of singers, peering anxiously at the masks on the floor. He finally came to the front from his hiding and squatted by the fireplace. Cautiously he placed the strange human skull-like gourd helmet over his head, threw a rough blanket around his

neck over his shoulders, and taking a planting stick in his hands assumed the kneeling posture which the Hopi take when they are planting on their farms, kneeling on one knee with the stick held vertically in his two hands. A second man who entered the kiva, in the same way donned the other helmet and without a word took his position near his predecessor. The songs of the assembled priests then became more animated and finally died down to a low murmur and ceased. The two personators manipulating their planting sticks in rhythm kept time to the songs. At the conclusion of which the singers filed out of the kiva, but as each man passed the fireplace he placed in the flat basket on the floor by the side of the kneeling figures a feather, symbolic of a prayer, for a successful harvest. As the last man left the room he halted for a moment at the fireplace, with one foot on the ladder rung and announced that in the spring, at planting time, a great ceremony to the planting god would occur in the fields to the west of Walpi. The prayers throughout this rite were particularly fervent, but so low they could not be heard even a few feet away. There was no loud talking and the faces of all were very serious as befitting the reverence for the beings addressed; many even went so far as to turn their faces away from the dread being to whom they prayed. After the departure of the men the two planting gods silently gathered up the feathered prayer offerings offered them, and departed.

The supernatural being called Masauu, also known as Eototo, was the chief cult being of the Fire people who migrated into the Hopi country, according to legends, from the East in prehistoric times. They formerly lived at a pueblo, now in ruins, three miles east of Walpi, called Sikyatki. A quarrel arose between Walpi and the inhabitants of Sikyatki, sometime before 1540, which eventually led to the overthrow of the latter pueblo, whose people were incorporated in the former. Their cultus supernatural, Masauu, transferred to the Hopi pantheon, is still from time to time personated by descendants of the ill-fated Sikyatki, now fused with other Walpi clans.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GRAVITY.—*Investigations of gravity and isostasy.* WILLIAM BOWIE. U. S. Coast and Geodetic Survey, Special Publication No. 40. Pp. 196, with 18 illustrations. 1917.

For a number of years the U. S. Coast and Geodetic Survey has been carrying on geodetic investigations of isostasy with special reference to the effect of isostatic compensation upon the deflection from the vertical and upon the intensity of gravity. Four reports on these investigations have appeared previously. The first one was in 1909 and the last one in 1912.

The present report has as its main features: (1) The observed value of the intensity of gravity at the stations in the United States, Canada, India, and Europe, and at a few scattered stations. (2) Discussions of the relations between the gravity anomalies and the topography, the large areas of erosion and deposition, the geological formation as indicated by the surface rock, and the elevation of the station. (3) So-called regional versus the local distribution of the isostatic compensation. (4) The determination of a gravity equation and of the earth's flattening and the depth of compensation upon each of several assumptions. (5) Summaries of the results of the field observations with the pendulums, and descriptions of the gravity stations. (6) Illustrations, in the pocket at the back of the volume, showing graphically much data resulting from the investigation.

The results of the investigation may be summarized briefly as follows:

1. The most probable depth of compensation derived from gravity observations alone is 95 kilometers. As the author believes that the best value determined by Hayford from deflection data is 97 kilometers and that each of these two values should have equal weight, the resulting best value from all geodetic data is 96 kilometers.

2. In the United States there was found a decided relation between the sign of the gravity anomalies and the coast, but there was not found any apparent relation between the anomalies and any other class of topography.

3. In the United States there was found a decided relation between the gravity anomalies and the Pre-Cambrian geologic formation. In both the United States and in India there was found a decided relation between the gravity anomalies and the Cenozoic formation. No relation between the gravity anomalies and the geologic formations was found in Canada.

4. It was found from certain computations and investigations that the local distribution of compensation of the topographic feature is in general nearer the truth than regional distribution of the compensation out to a distance from the station of 167 kilometers. It was not proven whether local distribution is more probable than a regional distribution out to a distance of 59 kilometers from the station.

5. The best formula, resulting from this investigation, by which theoretical gravity may be computed for any latitude at sea level was based upon 348 stations; it is

$\gamma_0 = 978.039\ (1 + 0.005294\ \sin^2 \phi - 0.000007\ \sin^2 2\,\phi)$ in which γ_0 is the value of gravity sought and ϕ is the latitude of the station.

6. From the constants of the above gravity formula, was derived the value of 297.4 for the reciprocal of the flattening of the earth. This value of the flattening is very close to other values recently derived from gravity data in the United States and elsewhere.

7. The cause of the greater part of the anomalies is believed by the author to be in general the deviation from normal in the densities in the outer portion of the earth's material and probably not far below sea level.

The titles of a number of articles dealing with isostasy or related subjects are given. W. B.

PHYSICS.—*A specific gravity balance for gases.* J. D. EDWARDS. Bureau of Standards Technologic Paper No. 89. Pp. 20. 1917.

The need of an accurate method for determining gas densities has been especially urgent in the natural gas industry. To supply this need the apparatus described in this paper was designed. The balance is enclosed in a gas tight chamber and consists of a beam which is supported on 2 needle points, and which carries on one end a relatively large globe and on the other a small counterweight. The gas to be

studied is introduced into the balance case and its pressure is changed until the beam balances. The density is computed from the initial and the final pressures. The balance is standardized by similar observations made with the case filled with air. J. D. H.

CHEMISTRY.—*Experiments in the destruction of fly larvae in horse manure.* F. C. Cook, R. H. Hutchison, and F. M. Scales. U. S. Department of Agriculture Bulletins 118 and 245. 1914 and 1915.

Experiments during 1915 in the destruction of fly larvae in horse manure. F. C. Cook and R. H. Hutchison. U. S. Department of Agriculture Bulletin 408. 1916.

These three bulletins cover experiments extending over three years searching for satisfactory larvicides for fly larvae to be applied to fresh horse manure (the principal breeding place of the house fly) which would be without extremely toxic properties and without injurious action on the fertilizing value of the manure. The study involved entomological, bacteriological, and chemical investigations.

Over 50 substances have been tested of which three have been found effective and practicable. Some were excluded because of their extreme toxicity, such as potassium cyanide. The three that are recommended are borax, hellebore, and calcium cyanamid mixtures with acid phosphate.

Borax in large amounts injures plant growth, hence should be applied only to manure that is not to be used as a fertilizer.

Powdered hellebore (*Veratrum album* and *V. viride*) applied as a solution is an effective larvicide and, because it is decomposed in the course of the fermentation, does not affect the fertilizing value of the manure even when excessive quantities are used.

Calcium cyanamid mixed with acid phosphate and kainit are effective and, if enough acid phosphate has been added to give an acid reaction, the nitrogen and ammonia of the manure will be retained. The mixture is an advantage in that it adds to the manure nitrogen, potash, and phosphoric acid. F. C. C.

METALLOGRAPHY.—*The structure of the coating on tinned sheet copper in relation to a curious case of corrosion of this material.* Paul D. Merica. Bureau of Standards Technologic Paper No. 90. Pp. 18. 1917.

The attention of the author has been directed to a case of local corrosion, or pitting, in tinned sheet copper roofing. The pits occur in

general along the lines of surface scratches and are apparently unrelated to the service conditions, and to the direction of rolling of the sheet. They appeared some eight or ten years after the completion of the roof. The tin coating on copper consists of at least three layers; viz., a thin layer of Cu_3Sn immediately next to the copper, than a layer of Heycock and Neville's constituent H, containing about 60 per cent by weight of tin, and finally, a layer of the eutectic of tin and copper, in which most probably is found any lead that may have been present in the tinning mixture. The constituents of these intermediate alloy layers are more electronegative than either the tin or the copper. Consequently, when the copper becomes exposed, as at the bottom of scratches on the surface, it forms together with the alloy layer a galvanic couple, electrolytic action sets in, and the copper at these points is corroded, forming the pits mentioned. P. D. M.

GEOLOGY.—*Relations of the Embar and Chugwater formations in central Wyoming.* D. DALE CONDIT. U. S. Geological Survey Professional Paper 98–O. Pp. 263–270, with 3 plates and 2 figures. 1916.

The Embar formation of central Wyoming, which lies between the Tensleep sandstone and the Chugwater formation, comprises several distinct facies, each of which is considered in detail, and some of the formational boundaries in the Bighorn Mountain region are redefined. In connection with the description of the gypsum and associated strata it is suggested that possibly conditions were favorable for accumulation of salt beds also. The chance of finding such deposits down the dip below the surface is believed to be sufficient to merit further investigation. R. W. S.

BOTANY.—*Maxonia, a new genus of Tropical American ferns.* CARL CHRISTENSEN. Smithsonian Miscellaneous Collections, **66**[9]: 1–4. 1916.

The type and sole species of this new genus, *M. apiifolia,* is a rather rare polypodiaceous fern of Jamaica and Cuba, described by Swartz in 1801 under Dicksonia, and since variously referred to Dryopteris (or Nephrodium) and Polystichum. From Dryopteris, in which it was last placed as a special subgenus by Maxon in 1909, it differs in the unique morphology and development of the indusium, as also in its strongly dimorphic leaves and peculiar rope-like rhizome. The last two characters recall Polybotrya, between which genus and a small subgroup of Dryopteris species it is somewhat intermediate. A subspecies, *M. apiifolia dualis,* occurs in Guatemala. P. C. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 783rd meeting was held at the Cosmos Club, February 3, 1917. Vice President BURGESS in the chair; 61 persons present. The minutes of the 782nd meeting were read in abstract and approved.

A letter signed by several members of the society, calling attention to the recently organized American Metric Association, was read.

Mr. ARTHUR W. CLIME, introduced by Mr. ALEXANDER GRAHAM BELL, presented a communication on *Photoelectric radiophonic experiments.*

Mr. BELL, in introducing Mr. Clime, spoke of the history of selenium. He referred to the remarkable property possessed by crystalline selenium of having its electrical resistance affected by light; and of the utilization of that property in the construction of the photophone. He also referred to the discovery made by the late Prof. W. G. Adams, of King's College, England, that light produced an electromotive force in crystalline selenium. Mr. Bell had suggested to Mr. Clime that this opened up a new field for scientific investigation and recommended him to follow out the experiments of Prof. Adams by applying the results to radiophonic researches. He had also pointed out to Mr. Clime that the remarkable properties of carbon in radiophonic work would well bear exploration.

Mr. CLIME then exhibited some of the radiophonic apparatus he has constructed, and spoke of the results that had been obtained. He showed a selenium cell which, when exposed to an intermittent beam of light, caused a telephone connected with it to emit a musical sound even when there was no battery in the circuit. The result he claimed was due to an electromotive force produced in the crystalline selenium by the action of light. He also showed a cell in which the selenium had been replaced by lampblack. So long as there was a voltaic battery in the circuit the telephone responded well when the lampblack surface was illuminated by an interrupted beam of light, but he was unable to detect any audible effect when the battery was removed. A cell in which a mixture of selenium and lampblack was employed was then exhibited. In this case the sonorous responses of the telephone were very loud even when no battery was used. The musical tone was clearly perceived when the telephone was held at a distance of several inches from the ear. On account of the magnitude of the sound produced by the selenium-carbon mixture, Mr. Clime predicted the possibility of producing, by the action of sunlight, an electromotive force of sufficient power to be of economic value.

Discussion. The paper was discussed by Messrs. ABBOT, BAUER, and WEED. Mr. SOSMAN inquired as to the nature of the effect of adding carbon. Mr. Clime stated that the increase in response seemed out of all proportion to the increase in absorption due to blackening the surface. Mr. BRIGGS asked about a lack of symmetry in the illuminated system, and Mr. SWANN spoke of observing small electromotive forces in very thin films of platinum illuminated by a beam of light not perpendicular to the surface. The chair expressed the thanks of the society to Mr. Clime for his interesting communication.

Mr. W. W. COBLENTZ then gave a paper on *Characteristics and comparative sensitiveness of various types of radiometers.*

The various types of radiometers were divided into three groups.

Group I includes radiometers which are nonselective in their response to stimuli of radiant energy of all wave lengths. In these instruments the radiant energy is absorbed and converted into heat. They include the Nichols radiometer, the thermocouple, the Boys radiomicrometer, and the Langley bolometer. In all these instruments the response is proportional to the stimulus, and they are well adapted for quantitative work.

Group II includes substances which have the property of decreasing in electrical resistance when exposed to radiant energy of short wave-lengths, especially visible and ultraviolet rays. The phenomenon depends entirely upon the wave-length of the light stimulus. Many substances are "light-sensitive," e.g., copper oxide, sulphides of antimony and silver, and crystalline selenium. The latter has been the most extensively investigated. Its sensitivity depends upon heat treatment, and varies with the intensity and wave-length of the light stimulus. After exposure to light for a few seconds, it requires a long time to recover its normal ("dark") resistance. It is not adapted to quantitative work.

Group III includes the photo-electric cells, substances which, when charged to a negative potential, lose their charge when exposed to light; especially violet and ultra-violet rays. This emission of electrons is a surface phenomenon, easily disturbed by oxidation of the surface. The photo-electric cells investigated consisted of potassium and rubidium. It was found that the response (galvanometer deflection) was not proportional to the intensity of the stimulus, but, differing from the selenium cell, this lack of proportionality of response does not appear to depend upon the wave-length of the exciting light. In 1907 Angström described a new method for studying solar radiation. By covering his pyrheliometer with a blue glass he was able to study atmospheric diffusion of solar radiation independently of the water vapor present. He obtained some very interesting data on the temporary variations in the solar constant. In view of the fact that the potassium photoelectric cell has its maximum sensitivity in the violet, the speaker tried it as a pyrheliometer. It was found entirely too sensitive (on only 2 volts) to be used with an insensitive d'Arsonval galvanometer. Using a higher voltage and a milliammeter, the

current released when the cell was exposed (through blue glass to reduce the intensity of the sun-light) was sufficient to overheat the wires and crack the glass cell. This investigation should be continued, using a less sensitive photoelectric substance.

In certain spectral regions the sensitivity of the selective-radiometers is far greater than that of the non-selective instruments. The sensitivity of the selective instruments seems spread in the non-selective radiometer over the whole spectrum, with a corresponding reduction to a uniform and much lower value. From published data it appears that a single crystal of selenium, 1 sq. mm. in area, is 100 times as sensitive as the best selenium cell. In connection with a 36 inch telescope such a crystal receiver could detect a candle at a distance of 350 miles. The photoelectric cell is probably even more sensitive than the selenium cell. However, these instruments are very insensitive in comparison with the eye, which responds to light having an intensity of less than 1×10^{-9} ergs.

Discussion. Mr. ABBOT spoke of some radiometers of very high sensitivity in which the alignment of small magnetic needles was changed by the thermal expansion of the parts holding them. Mr. SWANN spoke of obtaining readings by placing a Peltier junction beside a thermocouple and maintaining the thermocouple at a constant temperature by the Peltier effect. Mr. ABBOT spoke of increasing the sensitivity by cooling the apparatus in liquid air. Mr. COBLENTZ stated that temperature differences in the surroundings make it very difficult to get consistent results.

DONALD H. SWEET, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 564th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, January 27, 1917; called to order at 8 p.m. by President HAY; 45 persons present.

Under the heading of brief notes, Messrs. W. L. MCATEE and A. WETMORE made remarks on certain misconceptions as to the notes of some common species of birds and as to a theory of the migration of birds.

Under the heading exhibition of specimens, DR. O. P. HAY showed a metacarpal of a horse with well developed lateral metacarpals, and three fused metacarpals of a cow each with well developed digits.

DR. L. O. HOWARD commented on an enthusiastic antimosquito convention which he had lately attended in New Jersey.

The regular program consisted of two communications:

H. M. SMITH: *Exploitation of neglected aquatic resources.* Dr. Smith called attention to many forms of fishes not used as food by the American public, but which are of pleasing taste and of good food value. Many of these have long been used for food by Europeans especially about the North Sea. He gave a brief résumé of the discovery, disappearance, and rediscovery of the tilefish and of its successful introduc-

tion to the consumer through exploitation by the Bureau of Fisheries. He then described the dogfish and its habits destructive to other fish and the losses caused by it to fishermen. He told of the efforts now being made by the Bureau of Fisheries to market the dogfish as a food. Under the name of grayfish it is now being successfully canned and marketed by some of the New England fisheries and, during the winter months when salmon are unattainable, by some of the salmon canneries on the Pacific coast. The canned meat not only constitutes one of the cheapest forms of protein now available, but the livers of the dog-fish yield a valuable oil; the oviducts, eggs; and the skin a leather which has many possibilities. Discussion by Messrs. AMES, BEAN, and DOOLITTLE.

W. L. MCATEE: *Showers of organic matter.* Under this heading Mr. McAtee gave a review of the various apocryphal and authentic instances in which hay, grain, various insects, encysted animalcules, worms, frogs, toads, fishes, and birds had fallen from the sky. The explanation was offered that the objects had been carried aloft by violent currents of air.

The 565th meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, February 10, 1917; called to order at 8 p.m. by President HAY; 30 persons present.

Two formal communications were presented:

H. F. TAYLOR: *A mortality of fishes on the west coast of Florida.* During the months of October and November, 1916, by some obscure cause, vast numbers of fishes were killed in the region mentioned. It appears to be a recurrence of the phenomenon observed in 1844, 1854, 1878, 1880, 1882, 1883 and 1908. Of the dead fishes 63 species, representing 37 families, were identified. The animals killed were confined, with the exception of king crabs, sea urchins, and sponges, to the class *Pisces.* Various suggested causes were examined; foul Everglade water, diseases, and volcanic eruptions are inadequate explanations. Evidence at hand seems rather to show that the cause of mortality was the release of occluded bottom gases by small seismic disturbances, or possibly by abnormally large numbers of *Peridinii.* Mr. Taylor's paper was illustrated by lantern slide views of the region involved and of strips of shore showing the large numbers of stricken fishes. His paper was discussed by Messrs. HAY, BARTSCH, GOLDMAN, RADCLIFFE, and others.

PAUL BARTSCH: *Changes in the avifauna about Burlington, Iowa, 1885 to 1917.* From 1885 to 1893 Dr. Bartsch was resident of Burlington and an enthusiastic bird collector. In the ideal conditions found for birds at Burlington he had recorded 275 species. Since 1893 he has been a sporadic visitor to Burlington but has always retained his interest in the local avifauna. Passenger pigeons, Carolina parakeets, whooping and sandhill cranes, and trumpeter swans were found about Burlington, but are no longer seen. The same is true of the Mississippi kite, the swallow-tailed kite, wild turkey, and

prairie chickens, the latter in times past having been shot from the speaker's porch. The prothonotary warbler, once common, appears to have gone northward. New birds now found at Burlington have come from the west, such as western meadowlark and red-shafted flicker. Other newcomers are the tufted tit and Carolina wren. Many of these changes are due to human agencies, some are unexplainable. Dr. Bartsch's paper was discussed by Messrs. HAY, MCATEE, WILCOX, GOLDMAN, JACKSON, and others.

M. W. LYON, JR., *Recording Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 117th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club at 8 p.m., January 2, 1917, President T. H. KEARNEY presiding. Mr. C. W. WARBURTON was elected to membership.

Under Brief Notes and Reviews of Literature, Mr. W. T. SWINGLE called attention to a recent trip by Prof. E. D. Merrill of the Philippine Bureau of Science, to the vicinity of Canton, China, where 3000 botanical specimens were secured.

The regular program was devoted to the subject of Plant Introduction under which the following papers were presented:

The need of more foreign agricultural exploration. (Illustrated): DAVID FAIRCHILD. Attention was called to the need of more foreign agricultural exploration and to the fact that only a comparatively small amount of money had been expended in such work. The amount had seldom, if ever, exceeded $18,000 in any one year, and for the most part the expense had been much lower. The most successful type of agricultural exploration has been carried on by men who are interested in particular lines of agricultural work. Among those who have been called into the exploration work temporarily are Messrs. Kearney, Carleton, Hansen, Swingle, Cook, Collins, Oliver, Aaronsohn, Meyer, Rolfs, Bessey, Knapp, Mason, Scofield, Shamel, Dorsett, Popenoe, Young, Lake, Bolley, Shear, Tracy, and Fairchild. Attention was also called to the need of studying the methods of agricultural production in foreign countries, to some of the more important recent introductions, and to the difficulty in getting people to adopt new foods.

The wild relatives of our crop plants; their value in breeding; how to secure them. (Illustrated): WALTER T. SWINGLE. The importance of the wild relatives of our cultivated plants in effective breeding for such desirable qualities as hardiness, earliness or lateness of blooming or of ripening, disease resistance, extra vigor, etc. was discussed. Frequently these wild relatives were found to be inconspicuous plants quite unlike the cultivated forms in appearance and were often native in remote localities. The Australian desert Kumquat, *Eremocitrus glauca,* for example, was originally described under the genus *Triphasia* and afterwards transferred to the genus *Atalantia.* In neither of these

genera was it properly placed, since it is closely related to true citrous fruits and will hybridize with the cultivated forms. Not cursory inspection of botanical literature, but protracted critical study of the botanical relationships, was necessary to make plain the desirability of the introduction of this species for the successful breeding of hardy and drouth-resistant citrous fruits. Plants not so closely related to the cultivated forms have been found useful stocks upon which to graft cultivated varieties. A properly digested taxonomic knowledge of the wild relatives of our cultivated plants was found to be indispensable as a foundation for all efficient plant introduction and plant breeding.

The introduction of foreign plant diseases: R. KENT BEATTIE. American agriculture has been based largely on introduced plants. Only twelve of the two hundred and forty-seven species of cultivated plants studied by De Candolle in his *Origin of Cultivated Plants* are clearly indigenous to the United States. Diseases of American economic plants may be separated into two groups: (1) Those which have passed from native plants to the introduced hosts, such as pear blight; (2) Those which have been introduced, such as citrous canker and the chestnut bark disease. Plant disease may be introduced in three ways: (1) The diseased crop plant may be imported for commercial use; (2) The diseased crop plant may be imported for scientific purposes; (3) The spores of the disease-producing organism may be brought in on plants not affected by the disease.

Commercial plant introduction, except field crops and florist stock, has been under a system of permit and inspection. In most states, however, the inspectors were trained as entomologists rather than pathologists, and there has been little restriction on the commercial importation of fungus plant diseases, except in the case of specifically quarantined crops. Material imported by the U. S. Department of Agriculture has undergone rigid inspection and plants which show symptoms of disease or arouse suspicion have been treated or grown under restraint until danger was passed. During the year 1916 the Pathological Inpectors of the Federal Horticultural Board while examining the material imported by the U. S. Department of Agriculture found one hundred and sixty-three hosts affected with disease and determined one hundred and fifty-seven diseases on these hosts.

The protection and propagation of plant introductions: B. T. GALLOWAY. The rapid change in public sentiment in the matter of plant sanitation and plant hygiene and the need for a constructive policy in the matter of adequately protecting our crop plants, and at the same time not closing the doors to the development of new crop industries through the introduction of plant immigrants, was discussed.

The Office of Foreign Seed and Plant Introduction in the Department of Agriculture has received seeds and plants from all over the world. These seeds and plants were grown, propagated, and tested at four outlying stations. It has also acted as the agent for handling seeds and plants from foreign countries for other branches of the Department, for the experiment stations, and for many private and pro-

fessional experimenters throughout the country. It has recognized the dangers to our important crop industries and has endeavored to take such steps as, in the light of our present knowledge, will insure that nothing but plants free from parasitic enemies and transmissible diseases are distributed.

The practical questions now confronting the office are as follows: (1) The organization, development, and equipment of a central plant and seed receiving station where plant introductions and plant materials of all kinds may be received, inspected, treated, and held if necessary, under conditions that will safeguard the country, and at the same time not prove to be a bar to a safe and constructive development of new plant industries; (2) The discovery and application of methods of treating seeds and plants, cuttings, buds, bulbs, etc., in such fashion as will free them from parasitic enemies and transmissible diseases, and at the same time not injure them or completely destroy them; (3) The discovery and application of improved methods of reproducing plants by seeds and vegetative parts in such manner that they will be free from parasitic enemies and transmissible diseases; (4) The conducting of field tests and trials for the purpose of determining the healthfulness of new or promising plant immigrants, and their suitability for general distribution; (5) The great need of further knowledge of plant propagation and plant and soil sterilization in order to provide methods which are less empirical than those in use at the present time.

H. L. SHANTZ, *Corresponding Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 506th meeting of the Society was held in the Lecture Hall of the Public Library, Tuesday evening, February 6, 1917, at 8 o'clock.

Dr. J. WALTER FEWKES, of the Bureau of American Ethnology, read a paper on *Prehistoric ruins of the Mesa Verde National Park.* This communication was mainly taken up by an outline of the work accomplished by him, in the summer of 1916, under direction of the Bureau of American Ethnology, at the request of the Department of the Interior. After a brief introduction on the situation and physical features of the Park and a short account of archeological work already accomplished, the speaker described in detail the uncovering and repair of one of the large pueblo-like buildings of the Mummy Lake group, situated on the Government road, 4½ miles from the ruin known as Spruce-tree House.

The mound excavated is one of the largest of the group, and when the work began gave no indication of the form, size, and architectural features of the building it covered. After three months' work there was brought to light a rectangular structure, 113 feet long by 100 feet wide, three stories high, with an enclosed court on the south side. The ground plan showed the existence of four circular, ceremonial rooms compactly embedded in fifty rectangular enclosures which were for-

merly used for secular purposes. The remarkable feature of this ruin is the large size of one of the circular rooms, situated in the center of a compact group of chambers. From the wide southerly outlook this ruin has received the name, Far View House. It is a pueblo habitation; the first of its type ever brought to light on the plateau. The ruin was repaired, the tops of the kivas being treated with Portland cement to protect them from the elements.

After describing the various architectural details of the building Dr. Fewkes passed to a consideration of what he termed the morphology of the structure, or the comparison of it with other types, especially the cliff dwellings of the Mesa Verde. He declared that it is a new type of ruin for that region, and that there are evidences of many other examples of the same general character now indicated by mounds; we may say that formerly there were as many members of this type on the Park as cliff dwellings in the caves of the canyons. He considered in detail some of the arguments bearing on the relative age of buildings like Far View House, and the cliff dwellings, and came to the conclusion that the former were the more recent, and evolved from the habitations in cliffs.

Considerable time was devoted to a discussion and comparison of the so-called kiva or sacred room. He held that this chamber should be made the basis of classification of pueblo ruins, and that it was represented by the tower found widely distributed in Utah and adjacent regions of Colorado. He pointed out the wide-spread custom of dual styles of buildings among primitive races, one type being devoted to religious purposes, the other to habitations. He claimed that the former are always better constructed than the latter. He regarded the tower as a religious building and thought that the people who used it lived in dugouts or temporary habitations that have disappeared. In the earliest times these two types were separated, but in later stages in the evolution of buildings they became united, and habitations were constructed around the bases of the towers. Later in the course of development the central original building lost its tower-like form and became the circular kiva. Several similar architectural units, by union, formed a pueblo.

Dr. Fewkes pointed out that the great morphological similarity between Far View House and the pueblos with central kivas and towers, many miles away, had an important bearing on the distribution or diffusion of pueblo culture. He regarded the San Juan region as the nucleus from which the pueblos south and west originated, thus substantiating by archaeological evidence the legendary traditions of the inhabited and much modified historic pueblos. He claimed that there were two nuclei of distribution of house builders in the southwest, each arising in regions physiographically and climatically distinct, each possessed of different materials available for architectural advancement. One arose in the Gila Valley, the other in the San Juan; the former spread toward the north, the latter to the south. Both nuclei were extinct before the historic epoch. What remained, or

that which we now know as the culture of living descendants, is the product of acculturation, due to cultural contacts in this expansion. History can afford, therefore, only an imperfect picture. We must rely on archeology, mainly architectural, and ceramic remains, supplemented by ethnology, to discover the nature of the culture of these two original nuclei.

In a discussion of their distribution the speaker showed numerous illustrations of the prehistoric kivas, called towers, situtated in Hill Canyon, near Ouray, Utah. To these he gave the name, suggested by their site, Mushroom Rock ruins. Their more striking peculiarity is their position on the tops of inverted cones, or mushroom-like formations of rock, produced by the enormous erosion evident in the region where they occur. He said that this form of ruins was not morphologically a different type from towers, but their site was so unusual that it was convenient to designate them by this name.

While the important question of the antiquity of the cliff dwellings has not been satisfactorily answered by the observation made at Far View House, progress is being made in the accumulation of significant data bearing upon it. As long as this question remains unanswered the archeologist has plenty of research before him for many more years of field work in the Southwest.

The communication was illustrated with lantern slides.

The 507th meeting of the Society was held in room 44 of the New National Museum, February 20 at 4 p.m. The speaker of the afternoon was Dr. I. M. Casanowicz of the New National Museum, who presented a paper on *The fish in cult, myth, and symbol.*

Dr. Casanowicz said, "The fish, as the inhabitant of the mysterious, indestructible, never-resting water, early impressed man deeply, and was considered by him as the genius and representative of the life-producing element. Traces of the veneration of the fish, sometimes revealed in taboos, are found everywhere in ancient times and still exist in various parts of the world." An important center of ichthyolatry in antiquity, according to the testimony of classical writers, was Syria where a fish goddess under the name of Derketo-Atargatios was worshiped as a phase of the great Semitic mother goddess Astarte, being regarded as a personification of the fructifying power of the water. Reminiscences of this cult still survive in the cherishing of sacred inviolate fishes in some places near mosques.

Tales of the fish as a medium of transformation and incarnation of spirits and ghosts are met with among various nations, and in later times the fish seems to have been, next to the bird, a symbol of the departed human soul. The fish as carrier of man across the water was illustrated by the story of Arion and the dolphin as told by Herodotus, and by the Biblical narrative contained in the book of Jonah. Parallel narratives of a man being swallowed by a sea monster were quoted from Greek, Polynesian, and Cherokee lore.

The belief in the magical and apotropaic properties of the fish was

also found to be widespread. The fish was generally considered as a being of good omen, benevolent and beneficient toward man, and by reason of its own great fertility it was a symbol of increase and abundance. Various regions had their favorite species of fish which were endowed with supernatural qualities. Thus among the classical nations the dolphin was termed the "saviour fish" (piscis salvator). In the Far East (China and Japan) the carp was the fish of good omen, while among the ancient Irish the salmon was the "fish of wisdom," the mere sight of which brought healing.

Dr. Swanton introduced the discussion of the paper by calling attention to the fact that migrations of Indians were influenced largely by the food supply. Thus many tribes of Indians followed the rivers and streams because of the presence of fish. Dr. Michelson mentioned the legend of a miraculous fish among the Delaware Indians, and also noted a similarity between the ancient beliefs concerning the fish and those held by the North American Indians. Mr. E. T. Williams spoke on the use of the fish in Japan and China, the latter country considering it martial in character because of its fearlessness in proceeding against the current of a stream, and also because of its scales, which suggest a coat of mail.

Frances Densmore, *Secretary.*

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

LECTURES ON HEREDITY

A series of lectures on Heredity will be presented before the Washington Academy of Sciences during March and April, 1917. The first of these addresses entitled *Observed changes in hereditary characters in relation to evolution*, by Prof. H. S. Jennings, Johns Hopkins University, Baltimore, will be presented on Thursday evening, March 15th, at 8.15 o'clock, in the Assembly Room of the Cosmos Club, H Street and Madison Place.

Other addresses in the series will be given on the following tentative dates:

March 29: Dr. Oscar Riddle: *The control of the sex ratio.*

April 13: Prof. W. E. Castle: *The rôle of selection in heredity.*

April 26: Dr. Alexander Graham Bell: *The bearing of heredity on human affairs.*

Notices will be sent out before each meeting

Monday, March 19: The Anthropological Society, at the Public Library, at 8 p.m. Program:

Fay-Cooper Cole, Assistant Curator in the department of anthropology at the Field Museum of Natural History: *The pagan tribes of the Philippines.* (Illustrated.)

Saturday, March 24: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, March 28: The Geological Society, at the Cosmos Club, at 8 p.m.

Saturday, March 31: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

F. J. Bates and F. P. Phelps: *Rotation of the plane of polarization by quartz and iron at high temperatures.* 30 minutes.

F. E. Wright: *Application of polarized light to the study of opaque substances.* 20 minutes.

P. V. Wells: *A standard of turbidity.* 15 minutes.

Tuesday, April 3: The Botanical Society, at the Cosmos Club, at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh day of each month.

CONTENTS

Original Papers

Page

Electrochemistry.—The electrometric titration of zinc with ferrocyanide. F. Russell v. Bichowsky ... 141

Mineralogy.—Neodymium as the cause of the red-violet color in certain minerals. Edgar T. Wherry ... 143

Genetics.—A correlation between endosperm color and albinism in maize. J. H. Kempton ... 146

Ethnology.—An initiation at Hano in Hopiland, Arizona. J. Walter Fewkes ... 149

Abstracts

Gravity ... 159

Physics ... 160

Chemistry ... 161

Metallography ... 161

Geology ... 162

Botany ... 162

Proceedings

The Philosophical Society of Washington ... 163

The Biological Society of Washington ... 165

The Botanical Society of Washington ... 167

The Anthropological Society of Washington ... 169

Vol. VII No. 7

April 4, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

Manuscripts may be sent to any member of the Board of Editors; they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. VII APRIL 4, 1917 No. 7

MATHEMATICS.—*Note on multiple algebra: The reduction of real dyadics and the classification of real homogeneous strains.* EDWIN BIDWELL WILSON, Massachusetts Institute of Technology. (Communicated by Arthur L. Day.)

1. About ten years ago I printed an account of some parts of Gibbs's course of lectures on multiple algebra.[1] In the classification, or reduction to a canonical form, which was there established for dyadics no attention was paid to distinctions between real and imaginary. I had in mind at that time to give the extension of Gibbs's work in Vector Analysis[2] needed to obtain the reduction of real dyadics to type forms, but did not publish my results. I desire now to show how the algebraic methods used by Gibbs to find the general classification lend themselves immediately to the further subdivision relative to reality.

The sort of dyadic under consideration is (p. 11):[3]

$$\Phi = \alpha \mid \alpha^0 + \beta \mid \beta^0 + \ . \ . \ . \ ,$$

where the antecedents α, β, . . . are ordinary vectors and the consequents α^0, β^0, . . . are $(n-1)$-dimensional vectors in n-dimensional space. (The vertical bars serve as separators and

[1] WILSON, EDWIN B. *On the theory of double products and strains in hyperspace.* Trans. Conn. Acad. Arts Sci., **14**: 1–57. 1908.

[2] GIBBS-WILSON. Vector Analysis, pp. 356–367.

[3] The page numbers in the text refer to the memoir cited in Note 1. I here use an upper zero instead of a dash over a letter to represent an $(n-1)$-vector.

have no connection with Grassmann's Ergänzung.) The only kind of multiplication used in the work is the (progressive or regressive, single or multiple) combinatory product. That means that we work with the affine, not with the metric, group of linear transformations with one point fixed, i. e., with homogeneous strains.

2. The essential steps in the reduction of a dyadic are these:

(a) As there are only n^2 independent dyads, any dyadic must satisfy a polynomial equation, with numerical coefficients, of degree not exceeding n^2. Hence any dyadic satisfies an equation

$$\Lambda(\Phi) = \Phi^m + c_1 \Phi^{m-1} + \ldots + c_{m-1} \Phi + c_m I = 0$$

of *lowest* degree, I being the idemfactor.. This equation is unique for if there were two of like lowest degree, their difference would be of lower degree (pp. 15–16.)

(b) As any dyadic is homologous (commutative in multiplication, p. 14) with its powers and with I, the equation of lowest degree may be factored in the form:

$$\Lambda(\Phi) = (\Phi - aI)^p (\Phi - bI)^q (\Phi - cI)^r \ldots = 0$$

identical with that obtained in factoring the ordinary polynomial

$$\begin{aligned}\Lambda(x) &= x^m + c_1 x^{m-1} + \ldots + c_{m-1} x + c_m \\ &= (x-a)^p (x-b)^q (x-c)^r \ldots = 0.\end{aligned}$$

(c) If we set (p. 26)

$$\Phi - aI = \Psi,\ \Phi - bI = \Psi + (a-b)\ I,\ \Phi - cI = \Psi + (a-c)\ I,\ \ldots$$

and if we divide (by the ordinary algorism of long division, which is applicable here) the expression

$$(\Phi - bI)^q (\Phi - cI)^r \ldots = AI + B\Psi + \ldots + H\Psi^{q+r+\cdots}$$

into I, we have the result

$$\frac{I}{AI + B\Psi + \ldots + H\Psi^{m-p}} = \frac{1}{A} I + B'\Psi + \ldots + G'\Psi^{p-1} + \frac{\Psi^p P(\Psi)}{AI + B\Psi + \ldots + H\Psi^{m-p}}$$

where P is a polynomial of degree $m - p - 1$. Next, let (p. 27)

$$I_a = (AI + B\Psi + \ . \ . \ . \ + H\Psi^{m-p}) \left(\frac{1}{A} I + B'\Psi + \ . \ . \ . \ + G'\Psi^{p-1}\right)$$
$$= I - \Psi^p P(\Psi)$$

with similar expressions for I_b, I_c . . . . corresponding to each of the roots b, c, ... The dyadics I_a, I_b, . . . are partial idemfactors, their squares are equal to themselves, they are independent, the product of two having different subscripts vanishes ($I_a I_b = 0$), and the sum of all is the idemfactor I.

(*d*) The dyadic Φ may be written as a sum of terms (p. 28)

$$\Phi = \Phi I = \Phi \ (I_a + I_b + \ . \ . \ . \ )$$
$$= \Phi_a + \Phi_b + \Phi_c + \ . \ . \ .$$

where the product of any two vanishes ($\Phi_a \Phi_b = 0$). The dyadics

$$Z_a = \Phi_a - aI_a \ , \ . \ . \ . \ ,$$

are nilpotent, i. e., $Z_a^p = 0$. The series of powers (p. 29)

$$Z_a, Z_a^2, \ . \ . \ . \ , Z_a^{p-1}, Z_a^p = 0$$

have increasing nullities, but the change of nullity between two succeeding powers never increases.

The reduction of Φ has thus been simplified to that of nilpotent dyadics Z. Beginning with Z_a^{p-1} we may work back through descending powers to Z_a and hence to Φ_a. We thus find the familiar result that, when expressed in matrical or quadrate form, Φ consists of a set of terms along the main diagonal, with at most some terms in the next parallel partial diagonal (called shearing terms, p. 31).

3. What additional information is obtainable if the dyadic is real? The steps in the proof may be traced one at a time.

(*a′*) The equation of least degree must be real since it is unique—a complex equation is equivalent to two.

(*b′*) The complex roots of $\Lambda(x) = 0$ occur in conjugate pairs of the same multiplicity. Hence if a and b are conjugate imaginaries, p and q are equal.

(*c′*) If a and b are conjugate imaginaries, so are $\Phi - aI$ and $\Phi - bI$, and hence so must be I_a and I_b, for they are obtained by similar real operations applied to conjugate imaginaries.

(d') If a and b are conjugate, so are Φ_a and Φ_b, and Z_a and Z_b. If Z_a is reduced to a certain standard form, one form of the conjugate imaginary dyadic Z_b will be that in which each vector (antecedent or consequent) and each scalar in Z_a is replaced by its conjugate value. Hence the types of Z_a and Z_b or of Φ_a and Φ_b must be identical relative to the distribution of shearing terms.

The results thus obtained allow us to set up canonical forms for real dyadics which have imaginary latent roots. As the antecedents $\alpha, \beta, \ldots$ of the dyads occur in conjugate imaginary pairs, the consequents which form the reciprocal set $\alpha', \beta', \ldots$ (p. 8) also occur in conjugate imaginary pairs (since they are obtained by multiplication and division).

If there is a pair of simple roots, the corresponding terms in the reduced form of the dyadic are $a\, \alpha \mid \alpha' + b\, \beta \mid \beta'$ where

$$\alpha' \alpha = \beta' \beta = 1, \qquad \alpha' \beta = \beta' \alpha = 0,$$

owing to the relations between reciprocal sets. We may write

$$\begin{array}{ll} a = a_1 + a_2 i & b = a_1 - a_2 i \\ \alpha = \alpha_1 + \alpha_2 i & \beta = \alpha_1 - \alpha_2 i \\ \alpha' = \alpha_1^0 - \alpha_2^0 i & \beta' = \alpha_1^0 + \alpha_2^0 i \end{array}$$

with the reciprocal relations yielding

$$\begin{array}{ll} \alpha_1^0 \alpha_1 + \alpha_2^0 \alpha_2 = 1 & \alpha_1^0 \alpha_2 - \alpha_2^0 \alpha_1 = 0 \\ \alpha_1^0 \alpha_1 - \alpha_2^0 \alpha_2 = 0 & \alpha_1^0 \alpha_2 + \alpha_2^0 \alpha_1 = 0 \end{array}$$

when real and imaginary parts are separated. Hence

$$\alpha_1^0 \alpha_2 = \alpha_2^0 \alpha_1 = 0 \qquad \alpha_1^0 \alpha_1 = \alpha_2^0 \alpha_2 = \tfrac{1}{2}$$

If we set $\alpha_1' = 2\alpha_1^0$, $\alpha_2' = 2\alpha_2^0$, the sets $\alpha, \beta, \ldots$ and $\alpha', \beta', \ldots$ may be replaced by $\alpha_1, \alpha_2, \ldots$ and $\alpha_1', \alpha_2', \ldots$

On multiplying, the terms $a\, \alpha \mid \alpha' + b\, \beta \mid \beta'$ give

$$\begin{array}{lcl} a_1\alpha_1 \mid \alpha_1' + a_2\alpha_1 \mid \alpha_2' & & s \cos\theta\, \alpha_1 \mid \alpha_1' + s \sin\theta\, \alpha_1 \mid \alpha_2' \\ & \text{or} & \\ a_2\alpha_2 \mid \alpha_1' + a_1\alpha_2 \mid \alpha_2' & & - s \sin\theta\, \alpha_2 \mid \alpha_1' + s \cos\theta\, \alpha_2 \mid \alpha_2' \end{array}$$

if $a = se^{\theta i}$. This is precisely of the Gibbs cyclotonic form, as might have been anticipated. The linear transformation or strain is a combination of stretching with elliptical rotation.[4]

[4] An elliptical rotation of angle q is a projection of an ordinary rotation of angle q. See Vector Analysis, p. 349.

The proof here given differs radically, however, from that given by Gibbs[5] for the simple three dimensional case; it applies, moreover, to any pair of conjugate latent roots, simple or not, when shearing terms are absent.

In case there is a double complex root with shearing, the terms in the reduced complex form of the dyadic are

$$a\alpha \mid \alpha' + a\gamma \mid \gamma' + \alpha \mid \gamma' + b\beta \mid \beta' + b\delta \mid \delta' + \beta \mid \delta'$$

Multiplication shows that the corresponding real form is, in matrical notation, as follows:

$$\begin{matrix} s\cos\theta & s\sin\theta & 1 & 0 \\ -s\sin\theta & s\cos\theta & 0 & 1 \\ 0 & 0 & s\cos\theta & s\sin\theta \\ 0 & 0 & -s\sin\theta & s\cos\theta \end{matrix}$$

The extension to the case of multiple roots with various shearing terms is clear. In the matrix there are two-rowed determinants strung along the main diagonal, all alike; and parallel to the main diagonal there are strung along with any distribution (depending on the distribution of the original shearing terms) two-rowed determinants, all alike, and of the special form shown above; all other places are filled with zeros.

The transformation in the case of multiply complex roots with shearing might be called a cyclotonic shear. It consists of a stretch and of an elliptic rotation in a series of planes P_1, $P_2, \ldots, P_{k-1}, P_k$, the angles of rotation and the factors of stretching being the same for all, combined with a shift of the points in P_{h+1} parallel to P_h for at least some values of h. The amount of the shift is typical of the shear. For instance, in the case of a triple complex root with double shearing the vector

$$\rho = x\alpha_1 + y\alpha_2 + z\gamma_1 + w\gamma_2 + u\epsilon_1 + v\epsilon_2$$

suffers, in addition to the stretch and elliptical rotation, the shift

$$+ z\alpha_1 + w\alpha_2 + u\gamma_1 + v\gamma_2 .$$

[5] GIBBS-WILSON. Vector Analysis, p. 360.

MINERALOGY.—*Halloysite from Colorado.*[1] ESPER S. LARSEN, Geological Survey, and EDGAR T. WHERRY, National Museum.

In the upper workings of the fluorite mine at Wagon Wheel Gap, Colorado, two amorphous hydrous aluminium silicates have been recognized which agree more or less closely with halloysite as defined by Dana but differ from one another considerably in water content. One has essentially the composition of kaolinite, but is for the most part sensibly isotropic and has the index of refraction 1.557. It occurs in rather large amount as

TABLE 1

ANALYSES AND THEORETICAL COMPOSITION OF HALLOYSITE

	1	2	3	4
Al_2O_3	35.75	35.41	35.58	34.66
Fe_2O_3	tr.	tr.	tr.	......
CaO	0.80	0.73	0.77	......
MgO	tr.	tr.	tr.	......
K_2O	tr.	tr.	tr.	......
Na_2O	0.10	0.09	0.10	......
SiO_2	39.95	40.22	40.09	40.90
H_2O below 100°	8.55	8.66	10.73	12.22
H_2O 100°–400°	2.15	2.10		
H_2O above 400°	12.85	12.91	12.88	12.22
Total	100.15	100.12	100.15	100.00

1 and 2. Analyses of halloysite.
3. Average of 1 and 2.
4. Theoretical for $Al_2O_3 . 2SiO_2 . 2H_2O . 2Aq$.

TABLE 2

LOSS OF WATER BY HALLOYSITE[2]

TEMP. °C	PER CENT LOSS	TOTAL
20	Started	
30	6.40	8.60
40	0.90	
50	0.75	
60	0.50	
100	0.05	
110	0.00	
150	0.10	2.10
200	0.40	
300	0.60	
400	1.00	
Ign.	12.90	12.90

the matrix in which the mineral creedite is imbedded and has been called "isotropic kaolinite."[3] The other contains more

[1] Published with the permission of the Director of the U. S. Geological Survey and of the Secretary of the Smithsonian Institution.

[2] LOWENSTEIN (Zeit. Anorg. Chem., **63**: 88–101. 1909), found that halloysite from Laurium, Greece, lost 21.4 per cent H_2O at 110°–130° or over 97 per cent H_2SO_4, and 6.2 per cent above 130°, but most halloysites cited by Dana behave like the one here described.

[3] LARSEN, ESPER S., and WELLS, ROGER C. *Some minerals from the fluorite-barite vein near Wagon Wheel Gap, Colordo.* Proc. Nat. Acad. Sci., **2**: 360. 1916.

water, and is less abundant, forming a matrix for nodules of gearksutite. It is white and opaline to dull in appearance, and has a hardness of about 2. Under the microscope it is isotropic and has a variable index of refraction, averaging about 1.470 ± 0.010 when first examined, but increasing to 1.542 after standing for six months in a loosely stoppered bottle in a warm room.[4]

Analysis (by E. T. W.) yielded the results shown in Table 1.

TABLE 3

CHANGE IN OPTICAL PROPERTIES OF HALLOYSITE WITH LOSS OF WATER

HISTORY OF MINERAL	TOTAL H_2O. (APPROX.)	OPTICAL CHARACTER	n.
	per cent		
As first examined, two months after collecting	25	Isotropic	1.470±0.010
After standing six months in a loosely stoppered bottle	20	Isotropic	1.542±0.005
Heated for four hours to 65°C. This has the composition and index of the "isotropic kaolinite," which is evidently only a halloysite low in H_2O	15	Isotropic	1.555±0.003
Ignited powder, after standing one month	0	Partly isotropic but partly birefracting due to strain; clouded	1.541±0.003
Powder ignited, quickly cooled, and immersed in index medium (organic liquid of known *n*)	0	In large part isotropic but some fragments have birefringence of 0.01, with large axial angle	1.535±0.005

[4] Two halloysites represented by analyses A and B of U. S. Geol. Survey Bull. 591: 341, were examined microscopically for comparison. That represented by analysis A, from Horse Cove, Hart County, Kentucky, is pale pinkish in color and opaline in appearance. Much of it is weakly birefracting and large areas extinguish much as a unit but with a wavy effect, probably due to strain. The index of refraction is about 1.549 ± 0.003. The halloysite represented by analysis B, from Edwards County, Texas, is chalky in appearance, largely isotropic, and has an index of refraction of 1.556 ± 0.003, but contains admixed a considerable amount of birefracting kaolinite. However, to what extent their indexes have changed since analysis is unknown.

The water determinations (Table 2) were made by heating coarse powder in a covered platinum dish. The powder not used was kept for three months in a small vial in a balance case in which the air was dried with sulfuric acid, and was then found to have lost spontaneously 5 per cent of water. Obviously, the water in halloysite is in part only mechanically held. This part is given off very readily, and the resulting partially dehydrated material has a composition near that of kaolinite. The formula should therefore probably be written $Al_2O_3.2SiO_2.2H_2O.Aq$.

The effects of the loss of water on the optical properties are shown in Table 3.

The close approach of this and many other analyses of halloysite to the composition $Al_2O_3.2SiO_2.2H_2O.Aq$, combined with the results of optical examination given above, indicates that the material called halloysite is the amorphous mineral corresponding to crystalline kaolinite, holding through capillarity or adsorption more or less excess water.

ORNITHOLOGY.—*Diagnosis of a new laniine family of Passeriformes.* Harry C. Oberholser, Bureau of Biological Survey.

The peculiar shrike-like Madagascar genus *Tylas* has commonly been considered a member of the family Pycnonotidae. This disposition has probably been due to its nuchal hairs, and to the character of its external nares, which in general resemble those of the genus *Otocompsa*.

As Mr. W. P. Pycraft has recently shown,[1] this genus is really not closely allied to the Pycnonotidae. Neither is it a member of the Prionopidae, to which family Mr. Pycraft has proposed to refer it, apparently for want of a more satisfactory place. While in some osteological respects it resembles the Prionopidae, it has also resemblances to the Muscicapidae, and, on the whole, presents a very curious combination of characters, a condition reflected in the difficulty authors have had in referring it to the proper family.

That it does not belong in the Prionopidae is at once evident

[1] Proc. Zool. Soc. Lond., 1907, p. 376.

from the structure of the narial capsule alone, which in the latter group is fully ossified as in the Laniidae, leaving no external nasal fossa. Since there is no other family to which the genus *Tylas* is properly referable, it becomes necessary to provide one for its accommodation, as follows:

Tylidae, fam. nov.

Family characters.—Bill relatively slender and thrush-like, the culmen rather sharply ridged, the gonys rounded and but slightly and gradually ascending, the culmen straight for its basal half, gently decurved terminally; mental apex opposite anterior end of nostril; maxilla conspicuously hooked at tip, the commissural edge notched subterminally; nostril rather small, oval, non-operculate, exposed, and situated in the anterior end of nasal fossa; nasal capsule not ossified; feathering of forehead covering only basal portion of nasal fossae; narial bristles rather weak, but reaching to middle of bill; rictal bristles well developed; head entirely feathered; nuchal hairs present but short; tail moderately long, making up somewhat less than half the total length of the bird, square or slightly emarginate, and composed of moderately broad, stiffish feathers; wings much longer than tail but much rounded, the first (outermost) primary spurius, but more than half as long as the next, and neither secondaries nor tertials lengthened; feet and legs of moderate size and length; tarsi scutellate; femur pneumatic; ectepicondylar process of humerus much reduced.

The genus *Tylas* Hartlaub, comprising the following five species, constitutes this monotypic family: *Tylas eduardi* Hartlaub; *Tylas alfredi* Sharpe; *Tylas albigularis* Hartlaub; *Tylas fulviventris* Sharpe; *Tylas strophiatus* Stejneger.

ANTHROPOLOGY.—*Remarks on terms of relationship.*[1] TRUMAN MICHELSON, Bureau of American Ethnology.

Some years ago Kroeber[2] undertook to show that terms of relationship are linguistic and psychological phenomena. Re-

[1] Published with the permission of the Secretary of the Smithsonian Institution.

[2] Journ. Roy. Anthrop. Inst. Gr. Brit. and Irel., **39**: 77–84. 1909.

cently Rivers[3] has attempted to overthrow this view, holding that they are sociological phenomena, and consequently that it is entirely possible to infer marriage customs and social organization from these terms. Lowie[4] to a certain extent followed Rivers but has not followed the latter's survival-theories, nor is it likely that many American ethnologists will do so.[5] The present writer[6] developed Kroeber's linguistic thesis from a different angle, and also made a new point, namely, that terms of relationship are likewise disseminative phenomena. Specific data from Algonquian tribes were given to establish these facts. Lowie,[7] some months later, but quite independently, arrived also at this second theoretic position but extended the principle more broadly than the present writer had done. It is not without interest to note that we both assume that Iroquoian and Siouan influence has played a part in Algonquian terms of relationship. Sapir[8] briefly touches upon the methodological considerations and concludes that thoroughly satisfactory results can not be secured without linguistic analysis of kinship terms; that existing nomenclature may be retained in the face of sociological developments requiring its modification; that the factors governing kinship nomenclature are very complicated. Goldenweiser,[9] in his review of Rivers' *History of Melanesian Society*, says, "A set of terms must always remain a feature of language and as such it is subject to those influences which control linguistic changes as well as to the peculiar spirit of a particular language or linguistic stock." The present writer[10] has shown what extraordinary types of marriage we should have to assume existed formerly among the Piegans, were we to believe that marriage customs

[3] Kinship and Social Organization, 1914. The History of Melanesian Society, 1914.

[4] Proc. Nat. Acad. Sci., **1**: 346–349. 1915. Amer. Anthrop. n. ser., **17**: 223–239, 329–340, 588–591. 1915.

[5] Webster (Amer. Anthrop., n. ser., **17**: 175–177. 1915) is an isolated exception.

[6] Proc. Nat. Acad. Sci., **2**: 297. May, 1916.

[7] Holmes Anniversary Volume, 293. December, 1916.

[8] Amer. Anthrop., n. ser., **18**: 327, footnote 1. 1916.

[9] Science, n. ser., **44**: 826. 1916.

[10] Holmes Anniversary Volume, 333. 1916.

might safely be inferred from terms of relationship; whereas such marriages are fundamentally repugnant to the Piegans, and their terms of relationship are new, not old. This is, of course, a concrete example of one of Sapir's points. Recently Swanton[11] quite similarly brings forward data from Creek and Chickasaw which prove the unsoundness of such inferences.

The above has been cited to show that American ethnologists generally have taken a united stand against Rivers' one-sided attitude. I reopen the case because none of us has given absolute proof that kinship terms are borrowed. In another place[12] I have tried to prove that Cree has borrowed certain terms from Ojibwa; and somewhat similarly that Peoria has been influenced by Sauk, etc. I think the reasoning given there is sound, and as near absolute proof as we can expect to have in the case of prehistoric linguistic borrowing; yet it is not absolute in so far as we have no Cree nor Ojibwa records transmitted to us historically, extending over several centuries, showing absolutely that such borrowing took place. The same is true regarding Peoria. English is a good language to draw on for illustrative material to prove such a point, for it has been transmitted historically for several centuries. Every Indo-European philologist knows that *sister* is Scandinavian in origin, and that *cousin*, *niece*, *nephew*, *aunt*, and *uncle* are Romance. Furthermore all our terms of *-in-law* are directly or indirectly due to the latter's influence; *grand-father* and *grand-mother* are Romance in the first member of their compounds. Similarly Albanian *frat* "brother" is Romance in origin and is not a native word, as is shown by the phonetics. In the same way Hungarian *barát* "brother" is borrowed from Slavic, a case of borrowing across linguistic stocks. [Ojibwa *nimpāpa*, *nimāmā* (Fort William) are other illustrations of kinship terms borrowed across linguistic stocks.] These facts, long known, are brought forward simply because they seem to have escaped the attention of ethnologists. Delbrück[13] was well aware of the fact that Indo-European terms of relationship

[11] Amer. Anthrop. n. ser., **18**: 463. 1916 [1917].

[12] Proc. Nat. Acad. Sci., **2**: 297. 1916.

[13] Die Verwandtschaftsnamen. Leipzig. 1889. Also in Abh. phil.-hist. Klasse sächs. Ges. Wiss., **11**: 379. 1889.

are linguistic phenomena. Several terms that correspond phonetically occur in so many Indo-European languages that it is evident they belonged to the Indo-European parent language. The social organization of the peoples speaking the historical languages had nothing to do with it, as is shown by their diverse social organization. Nor can it be said that such German compounds as *Schwieger-mutter*, *Schwieger-vater*, *Schwieger-tochter* have replaced the Old High German words by reason of a change in social organization. Similarly, the fact that the Slavic word for "father" (Old Bulgarian *otьcь*) has a different termination than Greek ἄττα, Gothic *atta*, is of linguistic significance, not sociological. These data support my contenion referred to previously.[4]

Let us return once more to Rivers' position. On looking over the tables given at the end of volume 1 of Rivers' *History of Melanesian Society*, I am convinced that after all, he may have just as much a linguistic and disseminative problem as a sociological one. For example, the social organization of Mota, Banks Islands, and Eddystone, Solomon Islands, is entirely different; nevertheless the terms for *father*, *elder brother*, and *younger brother* are evidently the same. Furthermore, the distribution of slightly varying forms of the words *tama*, *tina* (*father* and *mother* respectively) even across linguistic stocks, points in the same direction. As I am not a specialist in Melanesian and Polynesian linguistics, I regret that I can not thresh this out to the end, and can only indicate a problem for others to solve.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Contributions to the geology and paleontology of San Juan County, New Mexico. 2. Vertebrate faunas of the Ojo Alamo, Kirtland, and Fruitland formations.* Charles W. Gilmore. U. S. Geological Survey Professional Paper 98–Q. Pp. 279–308, with 8 plates and 13 figures. 1916.

The known vertebrate fauna of the dinosaur-bearing beds in the San Juan basin in northern New Mexico consists of a considerable number of genera and species. The dinosaur-bearing deposits are subdivided into three formations—the uppermost, or Ojo Alamo, the Kirtland, and the Fruitland. No mammal, bird, or amphibian remains have yet been recorded from these formations. The dinosaurs were apparently the predominating vertebrates of these times, and they afford the best basis for a comparison with forms found elsewhere. The vertebrate remains from the Ojo Alamo, Kirtland, and Fruitland formations show beyond all question that they pertain to a fauna or faunas distinctly older than that of the Lance, and such evidence as there is contributes to the support of the contention that the Ojo Alamo sandstone is synchronous with the Judith River and Belly River formations as found in areas to the north. R. W. S.

GEOLOGY.—*Contributions to the geology and paleontology of San Juan County, New Mexico. 3. Nonmarine cretaceous invertebrates of the San Juan basin.* T. W. Stanton. U. S. Geological Survey Professional Paper 98–R. Pp. 309–326, with 5 plates and. figures. 1916.

Overlying the Pictured Cliffs sandstone with apparent conformity in the San Juan basin and underlying the Puerco formation is a group of nonmarine sediments, coal bearing in the lower part, which in many previous reports have been referred more or less doubtfully to the Laramie formation. The rocks occupying this interval are fully described

and a considerable area of them is mapped in a stratigraphic paper by C. M. Bauer, who recognizes in them three formations, the Fruitland formation containing all the coal beds at the base, the Kirtland shale in the middle, and the Ojo Alamo sandstone at the top. The invertebrates, which form the subject of the present paper, nearly all come from the Fruitland formation.

The list of species shows that the nonmarine invertebrates of the Fruitland formation include both a fresh-water fauna and a brackish-water fauna. The fresh-water fauna is especially notable for the greatly varied development of the genus Unio and for the abundance and considerable variety of the gastropods. The invertebrate evidence as a whole favors the assignment of the Fruitland formation to an epoch considerably later than Mesaverde and Judith River, and possibly somewhat earlier than Lance. The Fruitland can hardly be older than Fox Hills, and the sequence from the base of the Fruitland up to the top of the Ojo Alamo, which is conformable, may include the equivalents of everything from the Fox Hills to the Lance inclusive.

R. W. S.

GEOLOGY.—*Contributions to the geology and paleontology of San Juan County, New Mexico. 4. Flora of the Fruitland and Kirtland formations.* F. H. Knowlton. U. S. Geological Survey Professional Paper 98–S. Pp. 327–353, with 8 plates and figures. 1916.

The object of the present study is to ascertain the bearing of the fossil plants on the age of the series of coal-bearing and related rocks in San Juan basin, New Mexico. A brief historical setting for the geologic facts is given. The material on which the present report is based comprises 20 collections, of which 15 are from the Fruitland formation, 3 from the Kirtland shale, and only 1 from the Ojo Alamo sandstone. The bulk of the material comes from the lower or coal-bearing portion of the section, and much of this is preserved on a red baked shale, indicating proximity to coal. Of the 40 forms making up the known flora of the Fruitland and Kirtland formations, 16 have been found in other areas, and the list of these forms brings out the fact that no less than 15 are known to occur in the Montana. A further analysis of the list shows that 12 of the 15 forms occur in the Vermejo formation of Colorado and New Mexico, 10 occur in the Mesaverde, or rocks of about this age, in Wyoming and elsewhere, and 6 species are common to both these areas. On the basis of this showing the conclusion that the Fruitland and Kirtland formations are of Montana age, seems justified. R. W. S.

PHYTOPATHOLOGY.—*Mechanism of tumor growth in crown gall.* ERWIN F. SMITH. Journ. Agr. Research, **8**: 165–186, plates 4–65. 1917.

This paper, with its wealth of illustrations, records the results of a series of experiments testing the effects of various fluids and vapors on plants, undertaken for the purpose of shedding light on the mechanism of tumor growth in crown gall. As a result of these studies the author has come to look upon excessive cell proliferation as it occurs in plant neoplasms as due, not to the *direct* application of stimuli such as endotoxins and other by-products of the growth of the parasite within the host cells, but to their *indirect* action as the removers of inhibitions. Growth is the normal function of cells but under normal conditions is always inhibited beyond a certain point. *In the case of neoplasms we have an "inhibition remover that acts locally, disturbing tissue equilibriums within limited areas."* The author believes, furthermore, that this removal of growth inhibitions is not (or not wholly) due to a chemical action but partly at least to a physical one—viz., a locally increased osmotic pressure produced by the diffusion from the cells of various substances produced within them by the parasite as a result of its metabolism, together with the resultant counter movements of water and food supply, basing this belief upon the researches of Jacques Loeb in artificial parthenogenesis and fertilization, and on the results of his own experiments.

The substances produced by *Bacterium tumefaciens* in culture media containing dextrose, Witte's peptone, calcium carbonate, and water are ammonia, alcohol, acetic acid, formic acid, amines, aldehyde, and acetone. With several of these compounds, the author produced intumescences (both hypertrophic and hyperplasial) without the intervention of the organism itself. In addition to obtaining small tumors with crown-gall products (ammonia, dimenthylamine, and acetic acid) the author obtained overgrowths with a great variety of other substances; hence his conclusion that the response must be physical rather than chemical, i.e., due to removal of water from cells, which then divide.

The plants used were the castor-oil plant (*Ricinus communis*), tomato fruits, and cauliflower. The substances tested were injected hypodermically (Ricinus and tomato), placed in tiny open tubes inserted in the pith cavity (Ricinus, the wound being sealed with collodion or adhesive tape), or vaporized in a tight box containing 10.5 cubic feet air space in which the plants (cauliflower) were placed for a

few minutes. The substances tested were ammonia water, the various salts of ammonia, distilled water solutions of the acid component of these salts, distilled water, 10 per cent tannic acid, 10 per cent ethyl alcohol, 2 per cent sodium chlorid, 2 per cent sodium carbonate, 5 per cent sodium bicarbonate, 1/20 normal sodium hydroxid, 5 per cent ammonium bicarbonate, clear lime water, milk of lime (caustic), 1 to 10,000 mercuric chloride, 0.5 per cent carbolic acid, chloroform water, 1 to 1,000,000 copper sulphate water, 5 per cent grape sugar, 5 per cent cane sugar, and feeble alkaline vapors arising from dilute solutions of urea, ammonium carbonate, and the two ammonium phosphates, the mixed vapors of ethyl alcohol and acetic acid, and the vapor of secondary methylamine.

With all these substances, even distilled water, proliferations were obtained, but no killing of cells resulted except in the case of those coming into direct contact with too strong a solution. In Ricinus when ammonia was applied, the outgrowths were from the inner surface of the pith cavity, and occurred not only in the internode containing the chemical but in several to many others above and below.

Exclusive of the hyperplasia which appeared when vapor of acetic alcohol was used, one of the most striking effects obtained was the production of a stele within a stele in the pith of Ricinus by the injection of monobasic ammonium phosphate, and evidences of similar tendencies when ammonia was used. These facts together with the author's very successful production of teratoid tumors with *Bacterium tumefaciens* lead him to believe that fasciations and many similar phenomena are due to feeble infections by micro-organisms.

From these experiments the author concludes "that any soluble substance whatsoever, except a killing, a plasmolyzing, or an oxygen-absorbing substance, if continually liberated in excess locally in tissues not adapted to them would be able to induce tumor formation, and is convinced that had it been possible to apply these stimuli repeatedly, or better still, slowly and continually from within the cell—as does the parasite in crown gall—these striking proliferations would have developed into large irregular tumors, rupturing to the surface, i.e., into typical crowngalls. It is believed that this is the first time that galls have been produced with the chemical products of a gall-forming organism. The nature of the crown-gall products were determined for Doctor Smith by the Bureau of Chemistry of the United States Department of Agriculture from flask cultures set and controlled by him.

F. H.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 784th meeting was held at the Cosmos Club, February 17, 1917, President BUCKINGHAM in the chair; 69 persons present. The minutes of the 783rd meeting were read in abstract and approved.

By invitation, Mr. H. BATEMAN presented an illustrated paper on *The nature of chemical forces.* Sir Joseph J. Thomson's idea[1] of regarding chemical bonds as symbols for Faraday tubes may be developed successfully by considering solutions of Maxwell's electromagnetic equations in which the electric and magnetic forces become infinite on moving singular curves.

We must first of all try to understand the nature of potential energy and so we shall commence by studying the properties of a type of radiant field with singular lines starting from the origin and running in both directions along the axis of z. The electric force E and the magnetic force H being specified by expressions of type

$$\begin{aligned} H_x + i\,E_x &= f(\alpha, \beta)\frac{\partial(\alpha, \beta)}{\partial(y, z)} \\ H_y + i\,E_y &= f(\alpha, \beta)\frac{\partial(\alpha, \beta)}{\partial(z, x)} \\ H_z + i\,E_z &= f(\alpha, \beta)\frac{\partial(\alpha, \beta)}{\partial(x, y)} \end{aligned} \qquad (1)$$

where $\alpha = t - \frac{r}{c}$, $\quad \beta = \log\frac{x + i\,y}{r - z}$, $\quad r^2 = x^2 + y^2 + z^2$

it is easy to see that there is a radial flow of energy outward from the origin. The origin O may be regarded as a source or singular point at which neutral particles are continually breaking up into oppositely charged fragments which travel along the axis of z in opposite directions with the velocity of light.

Two neighboring sources O and O' whose singular lines overlap can produce radiant fields which interfere with one another in such a way that in the total field the only singularities lie in the interval OO'. This can be seen very readily by differentiating the expressions (1)

[1] The corpuscular theory of matter. Constable, London (1907). Phil. Mag., May. 1914.

with respect to z after putting $f(\alpha\beta)=1$ and writing down the values of the Jacobians. In particular, if the strengths $f(\alpha\beta)$ of the two sources are constants which are equal in magnitude but different in sign, then as O and O' approach one another the total electromagnetic field is in the limit equivalent to the electrostatic field of a point charge, the magnitude of the charge being the limit of the product OO' and the strength of one of the sources. The potential energy of an electrostatic field can thus be supposed to arise from the individual and mutual energies of two interfering radiant fields whose singular lines overlap.

When the strengths of the two consecutive sources OO' are not constant and not equal in magnitude, we obtain a type of electric point charge with two singular lines attached to it, the charges on the two lines being generally variable and together equal and opposite to the variable charge associated with the singular point. The case in which the charge on each singular line is the same is of chief interest.

Interference, or a cancelling out of singularities, can also be obtained with two point charges of this general type even when they are at a finite distance apart, provided their singular lines overlap. There must also be a simple relation between the magnitudes of the two charges at associated times; this indicates that it may be possible to give a mathematical proof that the mean value of the electronic charge is the same for all electrons. It is thought that this phenomenon may have some relation to chemical saturation. The present theory may be extended to the case in which the sources or point charges are moving and the singular curves are not straight lines pointing in opposite directions but are moving and changing in shape. The appropriate solution of Maxwell's equations is again of the type (1) but α and β are now defined by the equations.

$$[x-\xi(\alpha)]^2+[y-\eta(\alpha)]^2+[z-\zeta(\alpha)]^2=c^2[t-\alpha]^2,\ \alpha<t,$$

$$\beta=\log\frac{l_1(\alpha)[x-\xi(\alpha)]+m_1(\alpha)[y-\eta(\alpha)]+n_1(\alpha)[z-\zeta(\alpha)]-cp_1(\alpha)(t-\alpha)}{l_0(\alpha)[x-\xi(\alpha)]+m_0(\alpha)[y-\eta(\alpha)]+n_0(\alpha)[z-\zeta(\alpha)]-c(t-\alpha)}$$

where $\xi(\tau)$, $\eta(\tau)$, $\zeta(\tau)$ are the coordinates of the source at time τ and $l_0(\alpha)$, $l_1(\alpha)$, $m_0(\alpha)$, $m_1(\alpha)$, $n_0(\alpha)$, $n_1(\alpha)$, $p_1(\alpha)$, are functions of α connected by the equations

$$l_1^2+m_1^2+n_1^2=p_1^2 \qquad l_1(\alpha)\,\xi(\alpha)+m_1(\alpha)\,\eta(\alpha)+n_1(\alpha)\,\zeta(\alpha)-cp_1(\alpha)=0$$
$$l_0^2+m_0^2+n_0^2=1 \qquad l_0\,l_1+m_0\,m_1+n_0\,n_1=1$$

This theory may be developed and applied to problems of atomic and molecular structure. Thomson's Faraday tubes are regarded as singular curves of generalized point charges and an arrow may be used to signify the direction of the flow of energy along a Faraday tube. The result of chief importance is that an *even* number of singular curves should be supposed to start from each point charge, the number being proportional to the mean value of the charge. It is suggested that the valency electrons in an atom are each doubly con-

nected by singular curves with the same element of the positive nucleus, while the other electrons in the atom have their singular curves connected with *different* elements of the positive nucleus and, like the electrons in the nucleus, help to keep the elements of the nucleus together. A change in valency may be associated with a change in the distribution of the singular curves or Faraday tubes. Thus, if the carbon atom contains six outer electrons two of which generally serve to bind together two nuclear elements each carrying three positive charges, it would be possible for the valency of carbon to change from four to two but not to any other value. Similarly, if the nucleus of the oxygen atom contains four α-particles and there are eight external electrons, the only possible valencies for oxygen will be four and two. On the other hand, if the nucleus of nitrogen is built up from two α-particles and an element carrying a triple charge and there are seven external electrons, then it is possible for such an atom of nitrogen to exhibit valencies of one, three, four, or even five. Diagrams were shown illustrating these changes and suggesting a way in which energy may be locked up in an atom, and, as energy is generally radiated when a singular curve changes its shape and direction, it is easy to imagine how some of this energy is radiated away during a rearrangement of the singular curves. It should be noticed that when the variation in shape of a singular curve is caused by an oscillation of an electric charge at one end the width of the waves which travel along the curve increases at a rate which is roughly equal to the maximum velocity of the source. Now if the motion of the source is of type $x = a \sin \omega t$, the maximum velocity is $a\omega$ while the maximum acceleration is $a\omega^2$, consequently, if ω is very large, i.e., if the waves are of high frequency, the velocity $a\omega$ may be negligibly small while the acceleration $a\omega^2$ is appreciable. Thus the intense radiation which travels along the singular curve may be concentrated and act like a quantum of energy.

The analogy with Thomson's model of the benzene ring also suggests that arrangements of electrons and positive nuclei in which energy flows in a cycle along the Faraday tubes are generally very stable. The suggested theories of gravitation and atomic structure are reserved for later publication.

The chair expressed to Mr. Bateman the thanks of the society for the interesting paper.

Mr. L. B. Loeb then gave a paper on *The electron theory of valence.* The fact that the 87 elements now known can combine to form only a limited number of the nearly infinite combinations mathematically possible, is explained through the fact that certain very definite laws of combination seem to exist. The manifestations of certain regularities shown in these laws give rise to a property that is defined as valency, a property which seems to show a periodic variation with the atomic weight of the element. The forces causing these combinations are generally accepted as being electrical in nature. The history of this electrical concept of valency was briefly discussed, giving the contributions of the various discoverers up to 1906. Since 1910 marked

contributions have been made to the knowledge of the nature of the atom. The discussion of the bearing of these contributions (i.e., the existence of the positive nucleus in the atom as indicated by scattering and deflections of alpha particles by atoms, and the atomic number with its significant bearing on the nuclear charge, as shown by the experiments on the X-ray spectra of the elements and the chemistry of the radio-elements) on the nature of the forces acting between atoms, furnished the main body of the paper. The experimental results indicate that the atom is entirely electrical in nature with a highly concentrated electrically positive nucleus surrounded by neutralising negative electrons. Of these electrons those in the outer layer are active in chemical unions. The possibility that the chemical forces are due to the magnetic fields of electrons revolving in the atoms was shown for several different reasons to be highly improbable. The mode of action of the electrons in binding the atoms was discussed. The electrons were shown to be capable of binding atoms in two ways in the two great classes of chemical compounds, i.e., the compounds showing strong electrolytic dissociation, such as NaCl, and the compounds showing no dissociation, such as the organic compounds and molecules like O_2 and N_2. In the former class there seems to be a complete transfer of the electron from one atom to the other, the atoms being held together by the opposite charges on them due to the transfer. In the latter class the electrons probably lie midway between the two atoms, acting then as actual binding links between them. The two classes of binding merge into one another in compounds of intermediate type. The type of binding taking place between two atoms is governed entirely by the nature of the atoms as given by the periodic system. The bearing of the atomic number and of the periodic system on valency were then discussed. It was shown that according to an idea of J. J. Thomson, which has recently been elaborated by Kosseo, the valency activities of the elements may be explained by the assumption that the atomic number represents the nuclear charge, and that every atom, even at the expense of losing or gaining outer electrons and thus becoming electrically charged, attempts to achieve the outer electronic configuration of the inert gas which *immediately precedes* or follows it. Since the inert gases are assumed to have eight electrons in their outer stable layer, one can explain many regularities found in the periodic table, e.g. why it is that the sum of the negative and positive valencies are equal to eight. To make the facts presented more concrete, the speaker, after having pointed out its weaknesses, adopted the Rutherford saturnian atom with revolving electrons as the most satisfactory model. With this model it was shown by diagrams how, on a theory recently suggested by Kossel, various kinds of molecules might be built up from such an atom.

Mr. F. R. Bichowsky then spoke on *Valence and color*. He pointed out that the characteristic feature of chemical union is that the valence electrons are held in equilibrium by forces of attraction and repulsion, both of which are presumably electrical and both of which are due

solely to the atom nucleus. This means that to explain chemical union one must assume either that Coulomb's law does not hold for the total (resultant) electrical force acting on an electron in a molecule, or else that the electron is such that other than purely electrostatic forces can act on it. At the point of equilibrium there is acting on a valence electron a restoring force which measures the stability of the electron arrangement, i.e., the "reactivity" of the compound. The magnitude of this restoring force, as determined by valence considerations and as checked by information furnished by the visible and ultra-violet absorption spectra, shows that an arrangement of eight and not six forms the most stable grouping of electrons around the positive nucleus. This can not be explained on any plane model of the atom, as this grouping requires lack of radial symmetry in the electron or nucleus. Saturnian atom models are inadmissible. Either they will radiate energy at the absolute zero (contradicting thermodynamics) or else they can not radiate at all. New physical assumptions are needed to construct a successful atom model, as one can not be deduced from the ordinary solutions of Maxwell's equations, these solutions being incompatible with the properties of the positive nucleus as well as with its very existence. The static model of the atom is preferable as, although it requires new and startling assumptions about the nature of the electron and the positive nucleus, these assumptions need not contradict the classical theories of physics.

Informal communications. Messrs. W. W. Coblentz and W. B. Emerson presented to the Society a *Preliminary note on the selective reflection of tungsten.* The spectral radiation curves of incandescent tungsten filaments show peculiarities indicating the possibility of selective emission due to minima of reflection. The reflectivity curves of various metals, e.g. gold and copper, have in the visible spectrum indentations which give rise to strong selective emission in the incandescent metal. An examination of the spectral reflecting power curve of tungsten (in the form of plane highly polished mirrors) shows a small indentation at about 0.85 μ, which is greater than can be accounted for at present as being due to experimental errors. This depression in the reflectivity seems to be a property of the pure metal.

On account of the lateness of the hour, formal discussion was omitted.

Donald H. Sweet, *Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 313th meeting was held at the Cosmos Club, January 10, 1917.

INFORMAL COMMUNICATIONS

J. S. Diller: *More evidence as to the high temperature of the late eruption of Lassen Peak.*

REGULAR PROGRAM

George Otis Smith: *Geology and public service.* (Published in The Scientific Monthly, February, 1917.)

J. WAYLAND VAUGHAN: *Significance of reef coral fauna at Carrizo Creek, Imperial County, California.* The paper gave a brief presentation of the zoogeographic relations of the fossil coral fauna of Carrizo Creek, showing the fauna to be related to the faunas of Pliocene and post-Pliocene age in Florida and the West Indies and on the eastern coast of Central America. The geologic history of the Tertiary coral faunas of the southeastern United States, the West Indies, and Central America was summarized. The conclusion was announced that subsequent to the uplift which separated the Atlantic and Pacific oceans at the close of Apalachicolan (upper Oligocene) time, there was during late Miocene or Pliocene time connection between the Atlantic and Pacific oceans, perhaps in the vicinity of the Isthmus of Tehuantepec, and that the Atlantic coral fauna extended up to the head of the Gulf of California. Factors not clearly understood excluded the Pacific fauna from this area.

Discussed by MENDENHALL, BARTSCH, and MACDONALD.

The 314th meeting was held at the Cosmos Club, January 24, 1917.

INFORMAL COMMUNICATIONS

A. L. DAY: *Cooling of a lava surface.* On the basis of computations by C. E. Van Orstrand the bottoms of cracks 3 to 5 feet deep in the surface of an extruded lava should be glowing hot several days after the extrusion. Observers at Lassen Peak a few days after the recent eruption did not report any glow in the cracks.

Discussion: SIDNEY PAIGE described and submitted a large specimen as evidence of plasticity of the recent lava at Lassen Peak.

REGULAR PROGRAM

ARTHUR J. COLLIER: *Age of the high gravels of the Northern Great Plains.* The area discussed extends along the south side of the international boundary, from Redstone, 30 miles west of the North Dakota line, to Boundary Plateau, a distance of 175 miles. From Boundary Plateau it extends northwest to include the Cypress Hills, where the Canadian Geological Survey, in the years 1883, 1884, and 1904, collected fossils from Bone Coulee, which are Oligocene and equivalent to the White River in age. The formation is composed of more or less cemented gravel, sand, clay, and marl characterized by water-worn quartzite pebbles from the Rocky Mountains. It rests on a plateau whose elevation above tide is 4800 feet at its west end and 3700 feet at its east end, near Bone Coulee.

During the past two field seasons the United States Geological Survey has made an investigation of the lignite resources of the region, in the course of which fragments of vertebrate remains were collected from 27 localities. These fragments, which came from wells, railroad cuts, badger holes, and natural exposures, have been submitted to Dr. J. W. Gidley, who reports that they can not be older than Miocene nor younger than Lower Pliocene. The formation called the Flaxville,

from which this material was collected, is composed of brownish to ash-gray silt, sand and gravel, and white marl from a few feet to 100 feet thick. It is generally noncoherent but locally cemented with calcite and forms prominent outcrops, often marked by cross-bedding. The gravel is characterized, like that of the Cypress Hills, by material from the Rocky Mountains. It is found on four extensive plateaus ranging in elevation from 2700 feet, south of Redstone, to 3200 feet in the west side of Boundary Plateau.

Below the Flaxville level there are extensive areas, varying in elevation from 2500 to 2700 feet, in which the bedrock is generally near the surface. Several exposures of quartzite gravel interstratified with yellowish silt lie at an elevation of 2500 feet a few miles north of Milk River. A single fossil tooth collected from the gravel was submitted to Dr. Gidley, who pronounces it either a recent or Pleistocene horse. The erosion of these large areas is thought to have been accomplished in early Pleistocene time. Since early Pleistocene the streams have eroded their valleys, but this erosion was clearly before the last great glacial advance, and the valley floors are therefore regarded as having been formed during late Pleistocene and Recent times.

Discussion: W. C. ALDEN said the gravels are well rounded, and that erosion to a depth of at last 1000 feet occurred between the time of an older glaciation and the Wisconsin. J. W. GIDLEY suggested that the fossils in the gravels were derived from older formations.

J. C. HOSTETTER: *The linear force of growing crystals.* The literature on this subject shows that a loaded crystal will grow against a load and lift it. This was first demonstrated by Becker and Day in 1905 and, although their conclusions were attacked by Bruhns and Mecklenburg in 1913, the recent papers of Taber and of Becker and Day show definitely that the linear force exerted by growing crystals may develop large pressures and hence must be considered a factor in vein formation. In these latter papers the explanation given for Bruhns and Mecklenburg's failure to observe an elevation of a load placed on a crystal when an unloaded crystal was growing in the same solution was that the solubility of the loaded crystal was greatly increased by the pressure acting on it, and therefore the degree of supersaturation sufficient for the growth of the unloaded crystal was insufficient to cause growth of the loaded crystal.

We should here distinguish between pressure acting equally on both phases of a system—uniform pressure—and pressure which acts in excess on the solid—non-uniform pressure. The effects are quite different in the two cases, as has been pointed out by Johnston and Adams. The change in solubility produced by uniform pressure is very small as compared to the effect of temperature—1000 atmospheres so applied being equivalent to about 14°. Preliminary experiments on the effect of non-uniform pressure on solubility under carefully controlled conditions indicate that the effect of pressure acting on the solid but not on the liquid is much smaller than that brought about by the same pressure acting uniformly on solid and liquid.

Experiments with loaded crystals of potassium alum show that these crystals will lift their loads during growth, even if unloaded crystals are present, as long as the conditions of growth are controlled. The essential point to be considered is that the measure of lifting is the depth of whatever "cavities" may form on the upper or lower surfaces of the loaded crystal. With large crystals these height increments are very small compared to the growth on the top surface of an unloaded crystal and hence were probably overlooked in comparison with the latter. Other factors entering into the lifting effect produced are the relation of load to the crystallographic direction, and the habit of the crystal. The mechanism by which this lifting takes place is not at present known. Taber's view is that the lifting is caused by the expansion which takes place when the solid separates from the film of solution which is assumed to be always under the supporting edge of the crystal. Unfortunately, the experimental difficulties involved in testing this conclusion have not been overcome, so that the matter is unsettled. Another possible explanation is that the lifting effect is an expression of those forces responsible for crystal development. The experimental results obtained with crystals with painted surfaces indicate this explanation.

Discussion: E. T. Wherry described examples of fibrous crystals produced by crystal interference.

J. W. Gidley: *The origin of the mammals.* (No abstract.)

Discussed by R. S. Bassler.

The 315th meeting was held at the Cosmos Club, February 14, 1917.

INFORMAL COMMUNICATIONS

H. E. Merwin: *Diffusion and crystallization of metallic copper in crystalline sulphides.* After cooling from a molten state in a vacuum copper-iron sulphides may contain an excess of copper which slowly diffuses and crystallizes at ordinary temperatures. The growing crystals of copper open cracks in the solid mass in which they form.

REGULAR PROGRAM

D. F. Hewett: *The origin of bentonite and the geologic range of related materials in Bighorn basin, Wyoming.* Bentonite is a drab and cream colored bedded clay which until recently has been recognized only in the upper part of the Benton formation in Colorado, Wyoming, and Montana. Work on the west side of Bighorn Basin has shown that bentonite and clays closely resembling it occur at intervals from the base of the Benton formation of the Colorado group to the top of the Meeteetse formation or upper part of the Montana group. The beds occur, therefore, in a stratigraphic range of about 5500 feet in Bighorn Basin. A clay that closely resembles bentonite is also interbedded with tuffaceous rocks in an upper Eocene formation near Owl Creek.

In order to determine the mineral constituents of bentonite, six specimens were sized by the Bureau of Soils, and the proportions of each of

the more abundant minerals were determined in each size by immersion in oils of known index of refraction. In order that a comparison with bentonite might be made, seventeen specimens of sediment from associated beds were also sized.

Bentonite contains two classes of material. On the one hand, the sands and silt, which include grains that range from 0.005 to 1.0 mm. in diameter, are largely plagioclase (andesine), orthoclase, and biotite, with accessory quartz, glass, apatite, zircon, and agate. The grains of plagioclase and orthoclase are highly angular and are uniformly fresh. Most of the grains of quartz are also angular, but a few are well rounded, whereas the grains of apatite and zircon are fresh terminated crystals. On the other hand, the clay, which includes all grains less than 0.005 mm., shows by analysis water, silica, and alumina. The molecular ratio of silica to alumina is about 9 to 1, and therefore much higher than that in any of the common hydrous silicates of alumina. The dried powder is birefracting (biaxial negative) and the average refringence of different specimens ranges from 1.52 to 1.59. After the clay has been immersed in water, however, it is isotropic and therefore amorphous. This clay forms 73 to 86 per cent of the beds of pure bentonite, whereas the sands and silts make up the remainder. In the beds of impure bentonite however, the proportion of clay is lower and ranges from 54 to 61 per cent. One of the peculiar properties of the clay is its tendency to swell to six or eight times the original volume when immersed in water.

The clays, shales, and sandstones of the adjacent sediments which have been examined, are common types of quartzose sediments. Subangular grains of quartz and chert make up a large part of the coarsest sizes of most of the sediments, but a little orthoclase, biotite, plagioclase, and chlorite are commonly present. Quartz also forms an appreciable part of the finest silt and clay portions, but the birefracting clay of bentonite was not noted in any of the clay portions of these sediments.

In contrast with adjacent sediments, therefore, bentonite contains little if any quartz, but fresh plagioclase, orthoclase, and biotite predominate, and glass is locally present. The comparison of the mineral constituents of bentonite with volcanic ash from several localities, shows that whereas the variety and proportions of the minerals are strikingly similar, the proportion of glass grains in volcanic ash is represented in bentonite by the highly siliceous clay just described. The resemblance in mineralogy and chemical composition of the two classes of materials warrants the conclusion that bentonite is volcanic ash in which the glass has been hydrated and has lost most of its constituents except silica and alumina. An inquiry into the stratigraphic relations of the beds of bentonite appears to show that this alteration must have taken place before the ash was laid down. In the case of the Eocene clays, which are flood-plain deposits, the decomposition took place after deposition.

The geologic range of bentonite and the areas within which it is known to exist show that volcanic products probably make up a larger part of the Cretaceous sediments of the region than has been recognized heretofore. Beds of bentonite are present in the Bighorn Basin section, 3000 feet below the horizon equivalent to the base of the Livingstone formation in Montana, which is largely made up of volcanic materials. The source of these volcanic products cannot be determined, but probably is to be found in the region west of eastern Idaho and Utah.

Discussion: C. J. HARES spoke of the distribution and geologic relationships of bentonite. E. T. WHERRY outlined a process by which bentonite is made into a commercially important product for the softening of water. The bentonite is heated and treated with an alkali salt. The resulting material will exchange its alkali for the lime of hard water. F. J. KATZ called attention to the unusual process of alteration involved in the explanation of the origin of bentonite as presented.

FRANK J. KATZ: *Stratigraphy in southwest Maine and southeast New Hampshire.* The following sedimentary formations and groups have been established for the coastal region between the head of Casco Bay, Maine, and southern New Hampshire:

The Berwick gneiss, consisting of highly metamorphosed and recrystallized graywacke, quartzite, and thin micaceous beds, which are developed in a belt 1 to 10 or more miles wide extending southwest from Falmouth and Gorham, Maine, to and beyond Lee, New Hampshire. The formation is of undetermined but probably pre-Cambrian age.

An Algonkian (?) crystalline complex of quartzite, rhyolite, hornblende schist, and graywacke gneisses in Kittery, Maine, and Portsmouth, Newcastle, Rye, and North Hampton, New Hampshire.

The Carboniferous (Pennsylvanian?) Kittery quartzite, a thick formation containing thin-bedded quartzites and argillites in a belt about 10 miles wide along the coast from Saco, Maine, to Portsmouth, New Hampshire, and continuing thence inland in a southwesterly direction to the Merrimack River, where it forms part of the Merrimack quartzite of Massachusetts.

The Eliot slate, the rocks of the Casco Bay group, and the rocks of the Rochester, New Hampshire basin, which are developed in three separate areas but are approximately equivalent and conformably above the Kittery quartzite. Of these the Eliot slate, in Eliot, Maine, and Dover, New Hampshire, and extending thence southwest in two belts, consists of gray sericitic and silicious slates, argillo-quartzitic schists, calcareous beds, and carbonaceous phyllites. The Casco Bay group occupying an area about 12 miles wide and 30 miles long extending along the coast from Saco, Maine, to the head of Casco Bay, consists of the Cape Elizabeth formation of graywacke schists, gray gritty slates, sericite phyllites, and calcareous carbonaceous laminae; the Spring Point greenstone; the Diamond Island slate, a graphitic and pyritiferous quartz slate; the Scarboro phyllite, a carbonaceous sericite phyllite; the Spurwink limestone; the Jewell phyllite; and the Mackworth slate. The

rocks of the Rochester, New Hampshire, basin include the Gonic formation, in a belt 2 to 4 miles wide running from Sanford, Maine, to Barrington, New Hampshire, made up of graywacke schists, mica schists, and garnet-staurolite phyllites; the Rindgemere formation, occupying a broad area in Rochester, New Hampshire, and Acton and Lebanon, Maine, and lying northwest of the Gonic formation, is composed of quartzite, slates, and mica schists, but predominantly of carbonaceous sericite phyllites which contain chiastolite; and the Towow formation, in the town of Lebanon, Maine, and surrounded by the Rindgemere formation, consists of graphitic and pyritiferous quartz slates and carbonaceous sericite phyllite.

The igneous rocks are grouped as: (1) pre-Carboniferous granites, pegmatites, and diorites; (2) late Carboniferous or early post-Carboniferous schistose granodiorites; (3) post-Carboniferous biotite and muscovite-biotite granites, pegmatites, and hornblende diorites; and (4) probably Triassic trap dikes.

The distribution of these rocks was shown on maps on which the rocks of southwestern Maine and southeastern New Hampshire were systematically arranged for the first time. Earlier efforts had resulted only in conflicting petrographic categories without stratigraphic meaning. It is now known that instead of being pre-Cambrian or early Paleozoic rocks, as all had been supposed to be, more than half of the rocks, areally considered, are Carboniferous (Pennsylvanian?) or younger. The other rocks are in part certainly, and the remainder probably, pre-Cambrian.

Discussion: BROOKS, LA FORGE, PAIGE, LOUGHLIN, AMI, and WHITE called attention to the difficulties in establishing age relations, owing especially to the lack of fossils and to the disturbed and metamorphosed conditions of the rocks. The fact that a very definite trend in the structures had been established was emphasized as establishing relationships with the rocks of eastern Massachusetts.

H. E. MERWIN, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 118th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, at 8 p.m., February 6, 1917; forty-four members and fourteen guests present.

Dr. B. T. GALLOWAY, Mr. CHAS. F. DEERING, and Prof. W. D. CROCKER were elected to membership.

The program of the evening was *The relation of plant succession to forestry and grazing.*

Mr. C. G. BATES stated that foresters were first to apply in a practical way the knowledge of plant succession, and were in a sense the progenitors of this type of ecological science. The natural regeneration of forest stands in each of the climax formations of the Rocky Mountain region was shown to involve succession, there being in nearly all cases temporary control by a sub-climax following the disturb-

ance due to cutting. In practical forest management each formation was shown to present distinct problems in which the kind or degree of cutting is the controlling factor. The correct solution of these problems involves an intimate knowledge of the range of conditions under which the climax type can succeed. Direct seeding of forest trees on ground not recently occupied by the climax forest has usually resulted in failure.

Dr. J. V. Hoffman called attention to the successions in the forests of Washington and Oregon. Two types of succession were distinguished: (1) A type in which the production, distribution, germination of seed, and the establishment of seedlings are important. This type is dependent therefore on the presence of seed trees and progresses into an unoccupied area only 150 to 300 feet during each generation. The resulting forest is composed of trees of uneven age. (2) A type dependent primarily on the viability of seed and in no way dependent on remaining seed trees. The seeds produced by the old stand retain their viability when the forest is destroyed and germinate to form a new forest of the same type and of even-aged trees.

Mr. A. W. Sampson discussed succession as a factor in the management of the range lands of the Forest Service. Succession, or the alternation in the vegetative personnel of an area was found to occur whenever the natural conditions of the environment had been appreciably changed. Where the vegetative cover had been disturbed more or less seriously on pasture and range lands, and the disturbing factors subsequently eliminated or their intensity decreased, the vegetation, through successive invasions, gradually became more like the original.

In the administration of the range on National Forests with a view of maintaining a maximum forage cover, a clear recognition of the successional stages represented by the more conspicuous species is important. Certain species occur early and others late in the succession leading to the development of the climax or ultimate type. The conspicuous appearance of species which occur early and which are usually of little or no value for grazing, shows clearly that the pasture is being improperly used and that a change must be made in the management if the remaining desirable species are to be preserved. Studies of the growth requirements, the life cycles of the more important species, and the successional stages make possible the initiation of systems of management favorable to the invasion and succession of the species desired.

Mr. E. O. Wooton discussed the succession due to protection of a badly overgrazed area on the foothill slopes and adjacent sloping plains of the northwest side of the Santa Rita Mountains in southern Arizona. Quadrat collections were made at various stations at intervals during a period of eleven years. From this data the following successional stages were recognized: (1) Small weedy annuals in spring and annual grasses in summer and fall. (2) Short-lived perennial grasses. (3) Long-lived perennial grasses and a few species of perennial herbs

and very low undershrubs. Succession was most rapid on the upper slopes and the annual and perennial grasses gradually moved down the slopes into drier situations. Fire is the principal factor in preventing shrubs from replacing the grasses.

In the informal discussion Mr. G. A. PEARSON discussed the reseeding of yellow pine areas; Mr. J. T. JARDINE, how to maintain a most productive subclimax type of vegetation for sheep pasturage; Dr. DAVID GRIFFITHS, the effect of fires on the maintenance of the grass stage in Arizona; and Dr. H. L. SHANTZ, the importance of a knowledge of succession in the interpretation of the results of range management.

H. L. SHANTZ, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 566th meeting of the Society was held in the Assembly Hall of the Cosmos Club Saturday, February 24, 1917; called to order by President Hay at 8 p.m.; 50 persons in attendance.

Under the heading book notices, brief notes, exhibition of specimens, etc., M. W. LYON, JR., called attention to the latest edition of the International Rules of Zoological Nomenclature containing a summary of the opinions that have been rendered by the International Commission, compiled by Mr. John Smallwood of Washington.

Dr. R. W. SHUFELDT communicated a short paper entitled "Notes on the Trunk-fishes" and exhibited a specimen of *Lactophrys tricornis*.

Dr. L. O. HOWARD commented on the parent tree of an unusually fine variety of oranges and the extraordinary care taken of it by the owner during the recent cold weather in Florida.

Mr. WM. PALMER also commented on the effects of the recent "freeze" in Florida.

The regular program consisted of three communications as follows:

T. S. PALMER: *A pioneer naturalist in southern Florida.—Extracts from the diary of Titian R. Peale, 1825.* Dr. Palmer gave a detailed account of Peale's collecting trip in Florida in 1825 made for the purpose of securing birds for Prince Louis Bonaparte and mentioned and exhibited the species of birds discovered by Peale as new to science or new to the United States. He read extracts from Peale's diary and called attention to the other scientific expeditions of which Peale was a member, giving many interesting facts of his long life.

A. L. QUAINTANCE: *Some notes on the Aleyrodidae.* (No abstract.)

EMERSON STRINGHAM (introduced by R. E. Coker): *The shad and its relatives in the Mississippi river.*

Mr. Stringham said that herring-like fishes found in the Mississippi river possess more economic significance than formerly recognized. The two mooneyes (*Hiodon*) have flesh of excellent quality, but they are not sufficiently abundant to be of great importance. They eat principally insects, and feed both summer and winter, day and night, and they deposit their eggs as soon as the water temperature begins to rise in spring. The gizzard shad (*Dorosoma*) which serves as food

for other fishes is less abundant in the Mississippi proper than in slough and lakes. The river herring (*Pomolobus chrysochloris*), known as the host of a mussel of great value, feeds on insects when they are abundant, and on fishes at other times. It breeds early in summer. Fears are entertained that the fish and mussel may be excluded from the upper river by a dam at Keokuk, Iowa. The Ohio shad (*Alosa ohiensis*) seems clearly distinct from the Atlantic shad, but is sufficiently similar to be equally good food, though smaller. On the Mississippi this valuable resource is not utilized. The habits of the fish are similar to those of the Atlantic species, but it has not yet been proved to be anadromous.

M. W. Lyon, Jr., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 508th meeting of the Society was held at the New National Museum on March 6. This meeting was devoted to a general discussion, the subject being *Problems connected with the distribution of the aboriginal population of America.*

Dr. John R. Swanton introduced the discussion by stating that the subject divided itself into a consideration of the distribution of aboriginal population in America quantitatively and qualitatively. "Populations," said Dr. Swanton, "may be classified qualitatively according to their physical characteristics, languages, cultural features, social organization, and so on. Archeology has a bearing on all these." He gave as one of the principal problems to be considered the bearing of the data of each class on the generally admitted Asiatic origin of the American Indians and their diffusion from the northwest.

Dr. Aleš Hrdlička, speaking from the standpoint of physical anthropology, stated that the distribution of different physical types on the American continent has always been in this country one of the main problems of his branch of science. Morton, the father of American anthropology, classified the American Indians in two types: (1) The Toltec, or refined type, which included the Toltecs of Mexico, the Maya, and the mound-builders of the Ohio valley; (2) The Barbarian, which included all the less civilized, semi-nomadic tribes.

This classification, although imperfect, was shown in the course of time to have a good foundation. Roughly speaking we recognize today two great sub-types of the American aborigines which correspond in the main to Morton's groups. The "Toltec" strain shows an irregular but wide distribution over both Americas. Its main areas are portions of the northwest coast, a part of the Pueblo region, a large part of the more southern territory of the "mound-builders," all Yucatan, southern Mexico, Central America, the Antilles, the western region of northern South America, and the coast of Peru, with as yet undetermined areas in Brazil, and traces even farther south. The type is principally marked by brachycephaly. The second Morton group corresponds to the American dolichocephalic population which ex-

tends over vast areas from Labrador and Canada to Tierra del Fuego. Which of these two types is the older on the Continent has not yet been determined. The answer will doubtless differ in different localities. Besides these two, which may be called fundamental physical types of the American population, we now recognize a third group which, though closely related to the first or "Toltec," seems of much more recent introduction and development; this is the Athapascan. A fourth type, also of fairly recent introduction, is the Eskimo. Outside these four strains, all of which are related and proceed probably from one ancient stratum, we have discovered as yet in America no trace of any other Pre-Columbian population.

Dr. Truman Michelson, speaking on the linguistics of the Indians, said, "There is no single type of language, no fundamental structure that is the same in all linguistic stocks, though we find resemblances among them." The speaker stated that resemblances occur between the languages of northeastern Asia and those of certain North American Indians. "An important problem in linguistics," said Dr. Michelson, "is to determine whether resemblances between languages are genetic or borrowed." The distribution of linguistic stocks was indicated on maps.

Prof. William H. Holmes spoke briefly of the probable origin of the human race in southern Asia and the gradual spread from this cradle over wide areas through increase in numbers and intelligence. In passing northward the culture would be gradually modified and on reaching the Arctic it would be reduced to the hunter-fisher state exclusively known throughout the Arctic. In passing to America by the Behring Route migrating groups would carry with them only this single culture stage, but advancing southward changes would take place according to environment. Culture would take on one phase in the Great Plains region, another in the Mississippi Valley, still another in Mexico, and so on; and there would follow interchanges of culture elements between peoples and areas without end. We thus explain the complex conditions and great diversity of the Columbian period.

Dr. J. Walter Fewkes stated that the two great forces which have influenced the distribution of population in North and South America are (1) geographic, the course of migration being somewhat determined by the mountain ranges and rivers, and (2) the food supply, which depended on the climate. Dr. Fewkes called attention to the fact that language does not represent the cultural distribution of a people. Languages shrink and change, but archeology often represents culture in its highest manifestation and affords a permanent basis of study. Thus archeology indicates that two types of people once lived in the southwest. There were two foci of distribution, one in the San Juan valley and the other in the Gila valley. The food quest broadened the outlines of these groups and at the point of juncture there arose a mixed type which we now find along the Little Colorado, while in the original places the culture has entirely disappeared. Dr. Fewkes

spoke of the large and important cultural groups found in the West Indies where the Carib stock was preceded by another stock, the Arawak, both originating in South America. In the West Indes the root of the yuca bears the same relation to the food problem of the people that the corn bears in the southwest.

Dr. Walter Hough said that at the Discovery the tribes of America were identified with the environments in which they had settled and since that time only migrations of a minor character have taken place. The causes of extensive migration were thus conjectural but depended on basic facts of food, transportation, and artificial fire-making.

Mr. Francis La Flesche stated that the ancient rites of the Siouan stock show that the migrations of the people were influenced by the search for food. The first animal mentioned in these rites is the elk, succeeded by the deer, and later by the buffalo, at which period the mention of corn appears for the first time.

Frances Densmore, *Secretary*.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

LECTURES ON HEREDITY

The two remaining lectures of the series on Heredity previously announced by the Washington Academy of Sciences will be given at 8.15 p. m. o'clock, in the Assembly Room of the Cosmos Club, H Street and Madison Place, as follows:

April 13: Prof. W. E. CASTLE: *The rôle of selection in heredity.*

April 26: Dr. ALEXANDER GRAHAM BELL: *The bearing of heredity on human affairs.*

Notices will be sent out before each meeting

Tuesday, April 3: The Anthropological Society, at the New National Museum, room 44, at 4.30 p.m. Program:

LEO J. FRACHTENBERG: *The religious ideas of the northwest coast Indians.*

Tuesday, April 3: The Botanical Society, at the Cosmos Club, at 8 p.m. Program:

HAVEN METCALF: *The control of white pine blister rust* (illustrated). 30 minutes.

R. H. COLLEY: *Technique for the study of the white pine blister rust* (illustrated). 15 minutes.

CHARLES THOM: *Some natural groups in Aspergillus.* 20 minutes.

Saturday, April 7: The Biological Society, at the Cosmos Club, at 8 p.m. Program:

A. S. HITCHCOCK: *Botanizing in the Hawaiian Islands.*

Wednesday, April 11: The Geological Society, at the Cosmos Club, at 8 p.m.

Thursday, April 12: The Chemical Society, at the Cosmos Club, at 8 p.m.

Saturday, April 14: The Philosophical Society, at the Cosmos Club, at 8.15 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh day of each month.

CONTENTS

Original Papers

Page

Mathematics.—Note on multiple algebra: The reduction of real dyadics and the classification of real homogeneous strains. Edwin Bidwell Wilson 173

Mineralogy.—Halloysite from Colorado. Esper S. Larsen and Edgar T. Wherry 178

Ornithology.—Diagnosis of a new laniine family of Passeriformes. Harry C. Oberholser 180

Anthropology.—Remarks on terms of relationship. Truman Michelson 181

Abstracts

Geology 183

Phytopathology 187

Proceedings

The Philosophical Society of Washington 189

The Geological Society of Washington 196

The Botanical Society of Washington 199

The Biological Society of Washington 201

The Anthropological Society of Washington 202

Vol. VII

No. 8

April 19, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This Journal, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The Journal is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the Journal.

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* Volume I, however, from July 19, 1911 to December 19, 1911, will be sent for $3.00. Special rates are given to members of scientific societies affiliated with the Academy.

THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. VII | APRIL 19, 1917 | No. 8

PHYSICAL CHEMISTRY.—*A convenient form of autoclave.*
GEORGE W. MOREY, Geophysical Laboratory.

The following form of autoclave has been designed after considerable experience with autoclaves and bombs, and is believed to be superior to commercial forms in ease of construction, in manipulation, and in certainty of closure.

It consists of three parts: a photograph of these separate parts is shown in figure 1, and the assembled autoclave, in cross-section, in figure 2.

The cover, *B*, of the bomb, *D*, is held in place by being pressed against a projecting rim, *A′*, on the outer shell, *A*, by the bolt, *EE*. Following is a detailed description of each part.

The outer shell, *A*, is made from a piece of 4-inch standard pipe. On the upper end a shoulder, *A′*, $\frac{3}{8}$ inch thick, is welded with an oxyacetylene blow-pipe. Near the lower end of the pipe two opposite holes, $1\frac{1}{4}$ inches in diameter, have been drilled; their centers are $6\frac{3}{8}$ inches from the top. These holes are shown in section in figure 2, and are more plainly seen in figure 1.

Inside the outer shell is placed the bomb, *D*. It is made from a piece of $3\frac{1}{2}$-inch standard pipe, one end of which is closed by welding on an iron bottom, as shown. The other end is closed by means of the cover, *B*, the outer rim of which is pressed against the rim, *A′*, on the outer shell.

Special attention should be called to the type of closure. The washer, a ring of 0.8 mm. gold wire, is placed in the space, *C*,

where it is completely surrounded by metal, the sides of the cover being a close fit. This type of closure is the same as that described in a previous paper[1] for closing bombs at high pressures and temperatures. As emphasized therein, it is essential that the washer be completely enclosed by metal, so that when pressure is applied it cannot flow away.

Fig. 1. Photograph of the parts of the autoclave

The cover is held in place by being pressed against the projecting rim of the outer shell by the bolt, *EE*, which is threaded

[1] Morey. Journ. Am. Chem. Soc., **36**: 215–30. 1914; Zeits. anorg. Chem., **86**: 305–24. 1914.

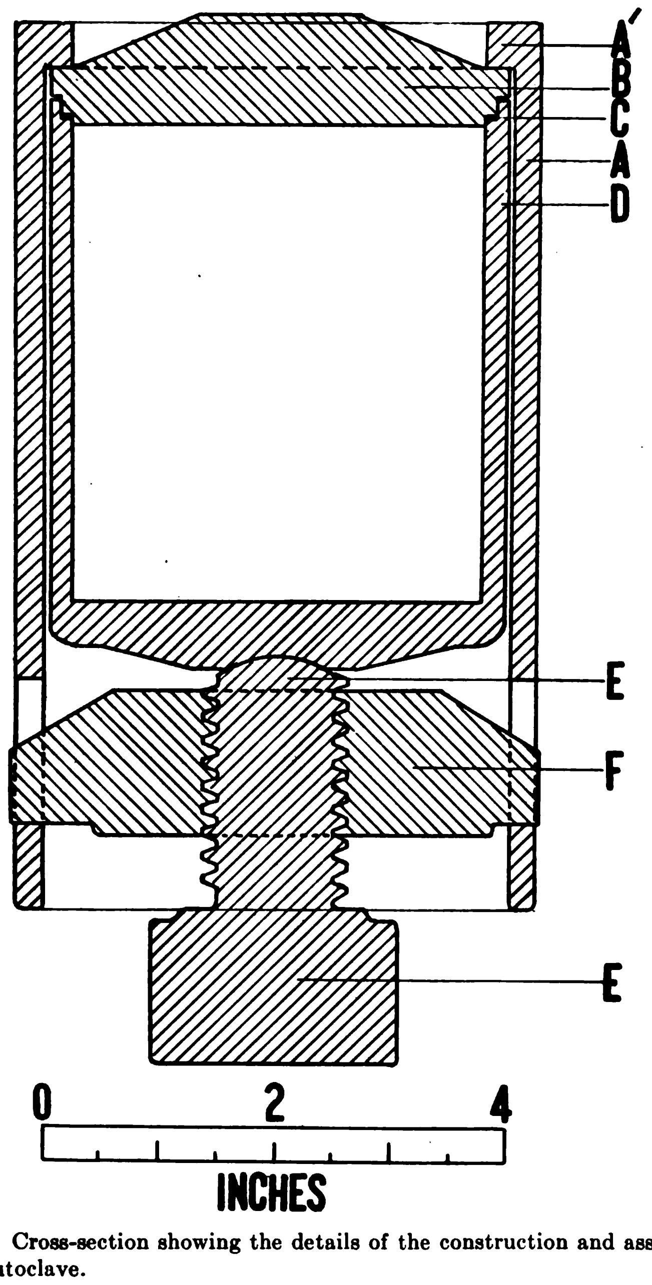

Fig. 2. Cross-section showing the details of the construction and assembling of the autoclave.

through the cross-bar, F, in the manner shown. The ends of the cross-bar are semicircular, the arc of the semicircle being downward and pressing against the bottom of the circular hole in the outer shell. When the bolt is turned, its rounded end, turning in the depression in the bottom of the bomb, forces the cover against the rim on the outer shell, thus compressing the gold wire in C, and effecting a tight closure. The ends of the cross-bar are cut away as shown, to enable it to be inserted after the bomb is in place.

The cover shown in the sketch is easily made, and it is convenient to have several for different purposes. Thus, one is provided with an exit tube and valve to permit the escape of the vapor, and another has both an exit tube and a pressure gage.

The above autoclave has been used for many experiments with aqueous solutions at temperatures up to 300° and has given complete satisfaction.

MINERALOGY.—*Leverrierite from Colorado.*[1] ESPER S. LARSEN, Geological Survey, and EDGAR T. WHERRY, National Museum.

Occurrence. During the summer of 1916, in the course of a geologic study of the San Juan Mountains under the direction of Whitman Cross, one of the authors (E. S. L.) collected specimens of a platy, foliated mineral, called "clay-gouge" by the prospectors, in the gold-silver mines of the old mining camp of Beidell, Saguache County, Colorado. The material was in considerable abundance in the dumps of the Buckhorn and Esperanza mines and is reported to occur in irregular bodies up to several feet across. A study in the office has shown it to belong to the leverrierite group of minerals. It is associated with gold and silver-bearing psilomelanite, pyrolusite, and quartz. The pyrolusite is in well-formed prismatic crystals with very perfect cleavages and is probably derived from manganite. The quartz is not abundant and is partly in well-formed crystals, up to an inch or more across, projecting into the

[1] Published with the permission of the Director of the United States Geological Survey and the Secretary of the Smithsonian Institution.

leverrierite, and partly of cherty character in coatings and reniform masses attached to the manganese oxides.

Physical properties. The mineral has many of the properties of ordinary "clay-gouge," but it differs in possessing a prominent micaceous cleavage, some of the cleavage pieces being several inches across and commonly bent. When dry it is rather brittle and has a hardness of about 1½. If large fragments are immersed in water they gradually break up, chiefly along the cleavage, into smaller pieces. After soaking for some time the mineral becomes smooth and plastic, and rather sticky. Under the microscope the fragments can be seen, however, to have retained their optical properties. On kneading the plastic mass the fragments are broken up, but still retain their properties. The plasticity can not be accounted for on the basis of the presence of any colloidal material, but seems rather to be due to the superposition of innumerable minute, soft, flexible plates, separated by films of water. The Colorado leverrierite has a vitreous luster and waxy appearance, and varies in color from nearly colorless to dark olive-buff (Ridgway 21‴) or russet-vinaceous (Ridgway 9‴).

Optica properties. A microscopic examination of a number of specimens showed them all to be essentially identical. The pale russet-vinaceous specimen selected for analysis is in bent plates up to an inch across, and appears to be homogeneous. The acute bisectrix is normal to the plates, the axial angle is sensibly 0, and the mineral is optically negative. The indices of refraction were measured by the immersion method. Fragments immersed in mixtures of clove oil and petroleum oil and quickly compared with the oil gave apparent values of $\alpha = 1.470 \pm 0.005$, β and $\gamma = 1.515 \pm 0.005$, but on standing in the oils the indices of refraction slowly increased. After standing for two days in mixtures of clove oil and cinnamon oil they reached a maximum constant value and matched the liquids in which they were imbedded with values of $\alpha = 1.558 \pm 0.003$, β and $\gamma = 1.602 \pm 0.003$. On removing the fragments from the liquid that had stood and placing them in a fresh liquid of the same index they still matched.

A similar change in the apparent indices of refraction, as measured by the immersion method, has been noticed in a number of other minerals. In some it is clearly due to the fact that the mineral has submicroscopic pores and that the apparent index of refraction is the result of the combined effects of the mineral and gas or water filling the pores; but if the pores are filled with a liquid having the same index of refraction as the mineral, the true index of the mineral can be measured.[2] For instance, the halloysite ("isotropic kaolinite")[3] from Wagon-Wheel Gap, Colorado, is clouded when first immersed, and the liquid can be seen to penetrate the grains, making them clear and increasing their index of refraction. The pores in the leverrierite are submicroscopic and the mineral appears clear, but the penetration of the liquid can be followed by the change in index of refraction in a zone from the border inwards.

Chemical properties. Qualitative examination having shown the material to be a hydrous aluminium silicate, it was analyzed quantitatively in the laboratory of the National Museum. The behavior of the water proved to be rather peculiar, so its relation to the optical properties of the mineral was studied first.

Behavior of the water. It is customary in mineral analysis nowadays to determine water of two kinds. That given off by heating to 105° or 110° is recorded as H_2O-, and that given off above one of these temperatures is recorded as H_2O+. This represents a decided advance over the older plans of determining only total water, or of drying the sample at 110° before weighing it out for analysis, and for many purposes may be adequate. But our knowledge of hydrous colloidal minerals, and even of many containing water of crystallization, will never be complete unless the actual temperature ranges over which the water is liberated both above and below 110° are recorded. While the boiling point of pure liquid water under a pressure of one atmosphere is 100°, the water held by a solid, even though not chemically combined in the strictest sense, may vaporize at a far lower

[2] Surface tension and similar phenomena may modify this.

[3] LARSEN, E. S., and WELLS, R. C. *Some minerals from the fluorite barite vein near Wagon-Wheel Gap, Colorado.* Proc. Nat. Acad. Sci., **2**: 364. 1916.

temperature than this, and again may be given off only at a much higher temperature.

In the case of the mineral here described the temperature of 100° possesses no significance whatever, as is clearly shown by Table 1, in which the loss at different temperatures is recorded. The coarsely powdered mineral was heated to each temperature in a covered platinum capsule for 2 hours.

TABLE 1

LOSS OF WATER FROM LEVERRIERITE FROM COLORADO

TEMP. °C	PER CENT H_2O LOST		TEMP. °C	PER CENT H_2O LOST	
20	Start		120	0.05	
30	2.05		130	0.05	
40	1.85		140	0.20	
50	2.10		150	0.35	
60	0.75		160	0.25	
70	0.45	Total below 110°, 10.75 per cent	170	0.25	
80	1.15		180	0.35	Total above 110°, 6.65 per cent
90	1.60		190	0.30	
100	0.45		200	0.35	
110	0.25		250	0.45	
			300	0.60	
			350±	3.15	
			ign.	0.30	Total water, 17.40 per cent

In interpreting the results it must be borne in mind that the amount of water lost at a given temperature depends on the fineness of grinding, the length of heating, the humidity of the atmosphere in which the heating is done, etc., so that too great significance should not be attached to such data. It is worth noting, however, that over one-third of the total water is given off below 50°, and nearly two-thirds below 110°. Nearly all the water is lost below 350°. By way of contrast it may be mentioned that a sample of halloysite recently studied by us[4] retained 12.9 per cent of H_2O at 400°.

[4] LARSEN, E. S., and WHERRY, E. T. *Halloysite from Colorado.* Journ. Wash. Acad. Sci., 7: 178. 1917.

Effect of dehydration on the optical properties. In order to determine the effect of dehydration on the crystal structure, samples of coarse powder were examined microscopically after being heated respectively for 8 hours at 65°, 5 hours at 130°, 2 hours at 290°, and 2½ hours at 360°. The loss of so large an amount of water would lead one to expect considerable change in the properties. However, the optical properties remained

TABLE 2

EFFECT OF DEHYDRATION ON THE OPTICAL PROPERTIES OF LEVERRIERITE FROM COLORADO

TEMP. °C.	PER CENT H_2O	β and γ	α	APPARENT[a] β and γ	APPARENT[a] α	REMARKS
20	17.4	1.602	1.558	1.515	1.470	Indices of refraction of grains immersed in oils appear to increase for several days before reaching the maximum value
75	10.0	1.600	1.555	1.495	1.46	Reaches maximum value in a short time
130	6.5	1.597	1.553	....	....	Quickly increases to maximum value
290	3.7	1.600	1.555	....	....	Quick'y increases to maximum value
360	0.2	1.603	1.559	....	....	Quickly increases to maximum value
Redness	0.0	1.54 varies ±0.03	1.50 varies	1.54	.....	Contains clouded areas. Rather deeply colored and pleochroic

[a] The apparent value as measured by the immersion method immediately after imbedding in an oil of that index of refraction.

practically unchanged up to 360°C, and there was only a moderate decrease in the indices after heating for half an hour at redness. The results are presented in Table 2. The mineral remains sensibly uniaxial, even after heating to redness, and the optic axis emerges normal to the plates. On heating, it gradually loses its waxy luster and becomes somewhat darker in color and more strongly pleochroic. It increases in hardness slightly and becomes rather brittle. The perfect cleavage becomes even more prominent than before dehydrating.

No satisfactory interpretation of this remarkable constancy of optical properties with wide difference in H_2O content occurs to the authors. The loss of water of crystallization or of chemically combined H_2O should have a considerable influence on the optical properties and would be expected to be accompanied with a complete change in all the crystal properties. Even the loss

TABLE 3

ANALYSES OF MINERALS OF THE LEVERRIERITE GROUP

	1	2	3	3a	4	5	6	7	8
SiO_2	47.28	47.84	47.56	789	47.95	49.90	50.55	49.4	48.43
Al_2O_3	20.27	20.88	20.57	256	32.67	37.02	19.15	45.1	41.63
Fe_2O_3	8.68	8.48	8.58		0.23	3.65			
MnO		0.24	0.24				4.40		
CaO	2.75	2.52	2.52	89	0.41	tr.	0.63		
MgO	0.70	0.91	0.80		0.46	0.30			2.13
Na_2O	0.97	1.58	1.28		2.47				
K_2O	tr.	tr.			0.24	1.13			
H_2O+	19.72	6.65	6.65		7.03	8.65	24.05	5.6	7.70
H_2O-		10.95	12.01		8.56	?		?	?
Totals	100.37	100.05	100.21		99.36	100.65	98.78	100.1	99.89
$Al_2O_3 : SiO_2$			1:2.76		1:2.34	1:2.11	1:3.95	1:1.86	1:1.94

1 and 2. Material from Beidell, Colorado. New analyses by E. T. W.

3. Average of 1 and 2.

3 a. Molecular proportions of 3.

4. Average of 2 analyses of "rectorite," Garland County, Arkansas. Brackett, R. N., and Williams, J. F., Amer. Journ. Sci., **42**: 16. 1891.

5. Leverrierite, Rochelle, France. Termier, P., Bull. Soc. Min., **22**: 29. 1899. Analysis made on material dried at 110°–130°. Older analyses show 13.21 and 18.0% of total water.

6. "Montmorillonite, var. delanouite," Millac, France. Quoted from Lacroix, A., Mineralogie de la France.

7. "Batchelorite," Tasmania. H_2O stated as "combined H_2O." Gregory, J. W., Trans. Austr. Inst. Min. Eng., **10**: 187, 1905.

8. Kryptotile. Quoted from Dana. The original article reports H_2O without a statement as to whether it represents total water or water above 100°.

of 17.4 per cent of "absorbed" H_2O would be expected to cause a considerable change in the values of the indices of refraction.

Composition. Two different samples shown by microscopic examination to be essentially homogeneous were analyzed by standard methods and yielded the results shown in columns 1

and 2 of Table 3; columns 4 to 8 give analyses of other members of the same group of minerals for comparison. The name leverrierite has been selected for the group because it has priority over all the others except kryptotile, which is, however, only known in indefinite mixtures.

All the minerals shown in the table are essentially silicates of aluminium with some Fe_2O_3 and RO. Assuming that the Fe_2O_3 and RO replace Al_2O_3, the ratio $Al_2O_3 : SiO_2$ varies from 1.86 to 3.95. The H_2O+ and the total H_2O also vary considerably, but no more than might be expected from determinations made under widely different conditions. Kryptotile is reported as having 7.70 per cent of H_2O. If this represents total water, it contains considerably less than the others. Batchelorite, kryptotile, rectorite, and the original leverrierite are near to $Al_2O_3.2SiO_2.2H_2O$ in which about half the H_2O is given off below 110°. The Colorado mineral is nearer to $Al_2O_3.3SiO_2.4H_2O$ and about two-thirds of the water is given off below 110°; while delanouite is near $Al_2O_3.4SiO_2.6H_2O$. However, there appears to be an almost continuous variation of the ratio $Al_2O_3 : SiO_2$ from 1.86 to at least 2.76. This can hardly be due to admixed impurities, as the authors have examined the Colorado mineral and the type rectorite, and have found them essentially homogeneous, and the descriptions of the analyzed leverrierite and batchelorite also indicate homogeneous material, although the delanouite examined by the authors contained some impurity while the description of the analyzed kryptotile indicates impure material. This variableness in composition within definite limits suggests that a mineral group is represented, or at least a species including several subspecies, as is the case, for instance, with muscovite. This view is confirmed by a comparison of the properties of the several minerals in Table 4.

The optical and physical properties of the six minerals, while not identical, are about as nearly alike as are the corresponding data for various specimens of muscovite and other complex minerals; and as in muscovite, the cleavage, optic orientation, optic character, and birefringence show comparatively little variation, while the axial angle and indices of refraction vary

within moderate limits. This similarity, together with the continuous variation in chemical composition, shows with reasonable certainty that all the minerals are members of a continuous

TABLE 4

PROPERTIES OF LEVERRIERITE AND RELATED MINERALS

	RATIO Al_2O_3: SiO_2	OPTICAL ORIENTATION	2v	α	β	γ	REMARKS
Batchelorite	1:1.86	....	....	.....	.....	.....	Foliated
Kryptotile[a]	1:1.94	X ⊥ cleav.	0–45°	1.558	1.593	1.594	Fibrous, platy
Leverrierite[b] France	1:2.11	X ⊥ cleav.	0–50°	1.554	1.582	1.582	Vermicular, micaceous
Rectorite[c], Arkansas	1:2.34	X ⊥ cleav.	38° ±	1.550	1.588	1.590	White, dull, tough. Resembles mountain leather. Interwoven fibers and plates. Rather plastic when wet
Material from Colorado	1:2.76	X ⊥ cleav.	0°	1.558	1.602	1.602	Luster vitreous to waxy, rather brittle. Platy. Very plastic when wet
Delanouite[d]	1:3.95	X ⊥ plates	Small	1.54	1.570	1.570	Not entirely homogeneous. Feathery plates

[a] New data on specimen from Waldheim, Saxony, kindly furnished by Colonel Roebling. The material closely resembles sericite.

[b] Published data of Wallerant. Other data gives the birefringence as low as 0.008.

[c] New data from U. S. Nat. Mus. specimen No. 80607. The indices vary. When first measured α = 1.500, β = 1.541, γ = 1.543. The indices appear to increase on standing in oils. (Cf. the Colorado mineral.)

[d] New data on "montmorillonite, Millac." Specimen kindly furnished by Prof. A. Lacroix. A red, clay-like mineral. Under the microscope it is seen to be made up of rather coarse, feathery plates or fibers. The best interference figures show that the mineral is optically negative and has a small axial angle. Some fibers are optically positive and have a large axial angle.

series with varying proportions of SiO_2 and Al_2O_3. This would not require any greater variation in the chemical composition than that due to the change in the water content, which, as was

pointed out above, takes place without a break in the crystal structure, as shown by the optical properties. Muscovite and other micas (to which leverrierite is probably related), show almost as wide a range in the ratio between the SiO_2 and Al_2O_3, as leverrierite; they also show like the latter but small variations in their optical properties.

Leverrierite and some of the minerals here united with it have usually been included in text books on mineralogy as varieties of kaolinite. However, Termier[5] has shown that it is undoubtedly a distinct mineral. He concluded that it is a muscovite in which the K_2O is replaced by H_2O, but since this conclusion is based on an analysis of the mineral dried at 110° it seems hardly justified; yet the cleavage and optical properties are certainly near those of the mica group, to which the leverrierite group is believed to be closely related.

Chemically it differs from kaolinite, chiefly in the fact that it retains only 7 per cent of its H_2O at 110° and very little at 350°, while kaolinite retains nearly all of its 14 per cent of H_2O up to 400 degrees. Optically leverrierite has higher indices of refraction, much stronger birefringence, and much smaller axial angle than kaolinite, and it is commonly found in larger plates.

The leverrierite group includes then, the micaceous hydrous silicates of aluminium with small amounts of Fe_2O_3, RO, and R_2O, in which the ratio $Al_2O_3 : SiO_2$ varies at least from 1.85 to 3.95; the H_2O content under normal conditions is from 15 to 24 per cent, of which all but about 7 per cent is given off below 110°. In physical and optical properties leverrierite resembles muscovite, but its cleavage is less prominent, it is rather brittle when dry and very plastic when wet, and its axial angle is commonly very small.

Summary. Leverrierite occurs in the veins of quartz and manganese oxide at Beidell, Saguache County, Colorado, in cleavage plates up to several inches across. It has a very perfect basal cleavage. It becomes plastic when wet. It is optically negative, practically uniaxial, and the optic axis emerges sensibly normal to the cleavage. The indices of refraction as

[5] TERMIER, P. Bull. Soc. Min., **22**: 27. 1899.

measured by the immersion method, immediately after imbedding in a liquid, appear to be $\alpha = 1.470$, β and $\gamma = 1.515$, but on standing in an immersion medium the liquid slowly penetrates the grains, probably displacing air and possibly some water, and after remaining several days in the liquids β and γ of the grains match a liquid with an index of refraction of 1.602, and α, one with an index of 1.558. These are believed to be the indices of refraction of the mineral. Loss of water, even to the extent of 17 per cent, causes no appreciable change in the optical properties, except a deepening of the color.

A chemical analysis of the mineral is given and the loss of H_2O at different temperatures. This analysis and analyses of rectorite, leverrierite, batchelorite, kryptotile, and delanouite are compared, and show some variation in the water content and, more especially, in the $SiO_2 : Al_2O_3$ ratio, which varies from 1.86 in batchelorite to 3.95 in delanouite. However, optical study of the six minerals indicates that they belong to a single group, probably related to the micas. Analyses of muscovite show almost as wide a range in the $SiO_2 : Al_2O_3$ ratio. The formula of the leverrierite group may be written $Al_2O_3.2 \pm SiO_2.2\frac{1}{2} \pm H_2O$.

MEDICAL ZOOLOGY.—*The carriage of disease by insects.*[1] L. O. HOWARD, Bureau of Entomology.

In his opening remarks the speaker called attention to the fact that the whole great field of the carriage of disease by insects has been developed within the last twenty years. He showed that in the standard medical works of twenty years ago, such as for example the 1895 edition of Osler's *Principles and Practice of Medicine*, there occurs absolutely no mention of insects in connection with the etiology of disease, either of man or of the higher animals; yet at the same time he showed that as early as 1889 Theobald Smith had discovered the causative organism of the so-called Texas fever of cattle (*Babesia bovis*) and that with the experimental aid of F. L. Kilbourne he had

[1] Address as retiring President of the Washington Academy of Sciences, delivered February 1, 1917. Abridged by the author.

shown that this organism was carried from southern cattle to non-immune cattle by the so-called southern cattle tick (*Margaropus annulatus*), the results of this experimental work having been published in 1893.

Even before this, however, Dr. Patrick Manson, now Sir Patrick Manson, had demonstrated the carriage of the parasitic worm, *Filaria nocturna*, responsible for certain of the diseases grouped under the name filariasis, from mosquitoes to man. Manson's discovery was, however, by no means so significant as that of Theobald Smith. The announcement of Smith's discovery, however, coming from a veterinary service and published in the annual report of the Department of Agriculture, unfortunately received little attention from the scientific world in general.

The initial discovery which attracted world-wide attention was that of Ronald Ross in India, who found that malaria is carried by certain mosquitoes.

The speaker here digressed in order to give his views concerning the recently agitated theory of the transmission of infantile paralysis by insects. He said:

The whole country was interested and alarmed at the occurrence of an unusual number of cases of infantile paralysis during the past summer (23,970 in all, with 2072 deaths out of a total of 7925 cases in New York City alone), and many theories were advanced concerning its method of spread. I must confess that when it was announced that the causative organism had been found in the intestinal passages as well as elsewhere and that it probably enters the body of the patient through the mucous membrane of the mouth and nose, I instantly thought of the house fly and the all too frequent contamination of exposed food by this insect, frequently fresh from intestinal discharges. But a second thought showed me that were such a method of conveyance of the disease possible the disease itself would be much more common and there would have been last summer very many thousands rather than many hundreds of cases. Then too, the not infrequent winter cases could not very well be fly-borne.

Mosquitoes have been suggested as carriers, and a well reasoned paper by Dr. Mark W. Richardson, of Boston, was published last September under the title "The Rat and Infantile Paralysis," the rat-flea of course being the theoretical carrier. But rat-fleas go to human beings only in the event of epidemic disease among rats, and nothing of the sort has been noted in connection with any of the larger epidemics of infantile paralysis.

Moreover in inoculation experiments reported by Flexner and Lewis, the virus is present in the blood of inoculated monkeys in such high dilution that the infection in a normal animal is accomplished only by inoculation of 20 cc. or more of the blood. If this holds under normal conditions, it becomes absurd to accuse any biting insect of the carriage of this particular disease, except in the possible event of the development of the organism in the body of the insect. While this possibility should be studied, the probabilities are against it. The impression which all of us in Doctor Flexner's audience at his lecture given December 28, in New York, gained, was I think that we are still greatly in the dark in regard to this disease, but that possible insect carriage must probably be ruled out.

It was then shown that it is necessary to divide the field under discussion into three categories.

1. Insects as simple carriers of disease, the accidental carriers as it were; that is, insects frequenting places where disease germs are likely to occur and conveying these in their stomachs or on their bodies to food supplies. This is notably illustrated by the house fly.

2. Insects as direct inoculators of disease. These are biting insects which feed upon diseased men or animals and carry the causative organisms on their beaks and insert them into the circulation of healthy animals. In this way anthrax is carried by biting flies; surra is carried in the same way, as is also the nagana or tsetse-fly disease of cattle. So also is bubonic plague carried in this manner by rat-fleas, but here there is more than a passive carriage, as is also the case with the tsetse-fly disease.

3. The third category, and this is perhaps the most important, includes insects as essential hosts of pathogenic organisms. These are the cases in which the parasitic organism undergoes its sexual generation in the body of its insect host and another, non-sexual, generation or generations in its warm-blooded host. To this class belong the malarial mosquitoes, the yellow-fever mosquito, and the rapidly increasing number of species that carry trypanomiases, leishmanioses, spirochaetoses, and the ticks that carry relapsing fevers and other fevers of man and animals, and the lice that carry typhus fever.

Under the first of these three categories the house fly was considered at some length, and cockroaches, ants (especially

the household ant), the latrine fly (*Fannia scalaris*), and other insects were mentioned rather incidentally.

Under the second category the biting flies that carry anthrax were mentioned, and illustrated (as, in fact, was the entire address) by lantern slides. Under this head also, carriage of bubonic plague by rat-fleas was discussed at some length.

Under the third category, insects as essential hosts of pathogenic organisms, attention was called to certain tapeworms which have alternate hosts in insects or other arthropods and domestic animals, especial mention being made of *Hymenolepis diminuata* which lives commonly in the intestines of rats and mice and has as its alternate hosts certain insects which feed in meal, so that man may become affected by eating dejecta of such insects in dirty cereals. The carriage of *Filaria nocturna* by *Culex fatigans* (*quinquefasciatus*), and Ransom's discovery of the house fly parasite *Habronema muscae* as a stomach parasite of the horse, and the pig parasite (*Echinorynchus gigas*) sometimes occurring in man, with its alternate hosts as the larvae of cockchafers in Europe and the common white grubs (larvae of Lachnosterna) in the United States, were described.

Then followed a longer consideration of mosquitoes and malaria, and mosquitoes and yellow fever.

Under the head of trypanomiases, the carriage of the nagana of African cattle by *Glossina morsitans* and the sleeping sickness of Africa carried by *Glossina palpalis* were mentioned, as well as the wasting disease of children in Brazil known as opilacao, caused by *Trypanosoma cruzii* and possessing a definitive host in the large biting true bug *Conorhinus megistus*

Then followed a consideration of insects and leishmanioses, ticks and spirochaetoses, including some detailed account of ticks and the Rocky Mountain spotted fever. A fuller consideration was given to typhus fever and lice.

Stating that the carriage of typhus fever by the body-louse was first demonstrated by Ricketts in the City of Mexico, where this discoverer lost his life from this fever in the course of his investigations, mention was made of the tremendous death rate from this disease during the last Balkan war in Serbia and

its destructive appearance in many p'aces during the present great war. It was shown that at first the information put out by the medical departments of the different armies was insufficient and in many cases illy based. Especial mention was made of the publications issued in England, France, and Germany, the extraordinarily detailed observations by Haase, made in Germany in the camps of Russian prisoners, receiving special consideration. He showed that more recently an intense investigation has been carried on in many places of all of the aspects of the biology of the body-louse. He showed that in the current number of the *Bulletin of the Pasteur Institute of Paris* (December 15, 1916) reviews had been found of seventeen papers, under the heading La Lutte Contre les Puces. One of these was written by a Japanese, four by Englishmen, seven by Germans, one by a Swiss, two by Frenchmen, one by a Russian, and one by an Italian. He pointed out especially the very perfect proof adduced in one of these articles of the transportation by wind of the body-louse, a very important point to be considered in sanitary measures.

In concluding, the speaker referred to a manuscript table drawn up by Mr. W. D. Pierce from the recent iterature, which indicates that discoveries have been recorded of 226 different disease organisms as carried by insects to man or animals; that 87 organisms are known to be parasitic in insects but not known to be transmitted, and that 282 species of insects are recorded as causers or carriers of diseases of man or animals.

The concluding paragraphs of the address are quoted:

But now we must stop. There are many subjects in the field which we have not touched. Tick paralysis, for example, is a most interesting and novel subject. This disease occurs in Australia, Africa, and North America. In Oregon thirteen cases have been found in the practice of a single physician. The attachment of a tick brings about progressive paralysis involving motor but not sensory nerves. It seems a unique malady. Hadwen and Nuttall, showing that it is not infectious and that there is apparently an incubating period in the tick, suggest a specific causative organism, but others hold to the theory of nerve shock.

Attention should also be called to the fact that, in spite of the host of discoveries already well established, there is a dangerous tendency

to exaggerate the importance of insect transmission, and to overlook, even in cases where insects may occasionally be concerned, the greater importance of other modes of infection. This is indicated by Sambon's theory of transmission of pellagra by Simulium—a theory which was advanced with enthusiasm on the ground that it fitted into the known facts in the epidemiology of the disease. It took two years of hard work on the part of members of the force of the Bureau of Entomology, working in collaboration with the Thompson-McFadden Pellagra Commission, to upset this theory in a thoroughly scientific manner. As has been pointed out several times of late, there is always considerable danger in conclusions based on epidemiological findings. Transmission experiments are necessary.

One conclusion must be drawn which can hardly be disputed: There is an enormous field for the entomologist in the careful study of all of the aspects of the biology of not only those insects which have already been shown to be disease carriers but of those which are likely to be implicated. It is to the trained economic entomologist that we must look for the methods of destruction of these insect carriers, and the prevention of this class of diseases lies at his door rather than at that of the physician. Either that, or sanitarians must be trained in what is now known as medical entomology.

ETHNOLOGY.—*Remarks on American Indian languages, a study in method.*[1] TRUMAN MICHELSON, Bureau of American Ethnology.

At the very beginning of this subject it should be stated that there is no single type of speech which holds good for all American Indian languages. The statement that all American Indian languages are both polysynthetic and incorporative, so confidently affirmed by the older writers, is false. The number of American Indian languages that are either polysynthetic or incorporative, is extremely limited indeed. I do not know of a single feature that may be said to be characteristic of all American Indian languages. Even so, a combination of certain features is quite sufficient to determine whether any given language is an American Indian language or not. It is this which enables us to say without any hesitation that Chuckchee, Koryak, and Yukaghir (which are spoken in northeastern Asia) are Americanoid languages. If they were spoken in America we would call them American Indian languages. They do not belong geneti-

[1] Printed with the permission of the Secretary of the Smithsonian Institution.

cally (as far as is known) to any American linguistic stocks, but nevertheless the totality of their features compels us to classify them with American Indian languages. To account for these facts we must assume either that these tribes are the descendants of the forefathers of American Indians who did not follow their brethren in the migration from Asia to America (for such a migration is firmly established by the facts of physical anthropology), or that there has been in comparatively recent times a migration backward from this continent to Asia. In as much as the bulk of American Indian languages are spoken on this continent, from a purely linguistic point of view the latter hypothesis is the most probable. But the essential fact in any case will remain unchallenged, namely, that we have Americanoid languages spoken in northeastern Asia.

Let us now turn to the almost unparalleled number of linguistic stocks on this continent. We have an apparent anomaly as compared with most parts of the world. The point at issue is whether such a multiplicity of stocks is original or not. In the first place, in the study of American Indian languages we are at a decided disadvantage as compared with the study, say, of Indo-European languages. Suppose that modern English and modern Russian were the sole survivors of the entire stock. It would be impossible to prove absolutely that they were both genetically descended from a common ancestor, no matter what we might surmise. It is only because we have continuous written records of both covering several centuries, and have the aid of other related languages which have even earlier records, that we can absolutely prove this. For this reason it is clear that there always will be American Indian languages whose genetic connection we may suspect, but which we can not prove. It may be urged that we can actually see what has taken place in the development and differentiation of languages which have been historically transmitted, such as Indo-European languages, and that we should apply the principles derived from such a study to American Indian languages in determining the stocks. The methodical error in such a procedure lies in this, namely, that there are less than a half a dozen, different stocks in

the entire world of which we have records going back continuously for more than a thousand years. The percentage of the total stocks so transmitted is altogether too small to afford a firm and sure foundation for such a mode of action. If we could establish from a minute study of the dialects of some dozens of stocks that the kind of differentiation, etc., was on the whole of a similar nature in these stocks, we would be entirely justified in applying the principles derived from such a study to the determination of the limits of stocks in American Indian languages and other stocks as well. Unfortunately such a study has not been made, nor is there any prospect of it being done in the immediate future.

We have a similar difficulty in the reconstruction of parent-languages of American Indian linguistic stocks. In the case of Indo-European languages we again can take advantage of principles derived from a study of the historical development of the separate members of the stock, and apply the results to the prehistoric period. We can not do this in the case of American Indian languages. The nearest approach to this would be a very minute study of the dialects of known stocks. In some cases there is no doubt that this would even largely counterbalance the difficulty spoken of. For example, most of the dialects of the Algonquian stock are so closely related that it can readily be ascertained in at least many cases what is archaic and what is secondary. Thus it is certain that the Fox *e* and *i* vowels are more primitive than the Ojibwa *i* vowel, and that the terminal vowels preserved in Fox, Sauk, Kickapoo, Shawnee, and Peoria, but not appearing in Ojibwa, Ottawa, Potawatomi, etc., are archiac.[2] Hence these features are to be ascribed to the Algonquian parent language. However, we can not know that precise quality of the prehistoric *e* and *i* vowels. Similarly the combination of a sibilant followed by a surd stop in Cree is more archaic than the correspondents in many of the related languages, and so is to be likewise ascribed to the parent language. (The actual proof that the Cree combination is more

[2] Amer. Anthrop. N. S., **15**: 470. 1913; this JOURNAL, **4**: 403. 1914; Ann. Rep. Bur. Amer. Ethnol., **28**: 247. 1912.

archaic is too complicated to be given here, as it would of necessity be altogether disproportionate to the length of this paper.) Naturally, in some instances, absolute proof would be wanting. Thus in certain cases Ojibwa *nd* corresponds to Cree and Menominee *'t*, Fox *t*. It can be easily shown that the Fox *t* in this case is in all probability unoriginal; and most philologists will assume that Ojibwa *nd* is more archaic than Cree and Menominee *'t*. But probability and assumption are not the same as proof.

A further obstacle to the reconstruction of the parent languages of American Indian stocks is our frequent inability to formulate phonetic laws in a manner such as is demanded by all modern Indo-European philologists. These contend that phonetic laws in themselves admit of no exceptions; and that wherever we find apparent exceptions, there is some extraneous reason, or reasons. The historical study of the individual Indo-European languages shows that analogy and the like have been potent factors in transforming them, and are fully as important as the actions of phonetic laws. For example late Latin *potēbam* is not a phonetic transformation of Latin *poteram*, but is due to the influence of other imperfects in *bam* preceded by a long vowel. For this reason we are justified in extending the principles derived in this manner to the prehistoric period, to harmonize discrepancies among the historical languages which cannot be accounted for by phonetic laws. Thus the Italic languages have an ablative singular of *ā* stems in *ād* (retained in Oscan and early Latin; final *d* lost in classical Latin by phonetic law). The collective study of Indo-European languages shows conclusively that the ablative singular of *ā* stems was the same in form as the genitive. Since the same study demonstrates that *o* stems in the Indo-European parent language had an ablative singular in *ōd* (preserved in early Latin; *d* lost phonetically in classical Latin), and that no other stems in the Indo-European parent language had a special case form for the ablative singular; and since we know that in historical Indo-European languages analogy has been a potent transforming factor, we have an entirely legitimate right to assume that the Italic languages developed an *ād* abla-

tive singular for *ā* stems by the influence of the *ōd* ablative singular of *o* stems. In one sense the proof is not absolute, but it is as absolute as it is possible to give when dealing with prehistoric phenomena. It must be admitted that at times even Indo-European philology is at sea, and that pure'y subjective speculation may come into play. Happily these instances are rare. These remarks are inserted because although the facts are well-known to Indo-Europeanists, they are largely unknown to Americanists.

The bearing the above has on the problems of American linguistics is this: since American Indian languages have not been transmitted to us in the manner that Indo-European languages have, we do not know what has disturbed phonetic laws in many given cases, and for the methodical reasons outlined above, we are not justified in assuming that the same influences have been at work in American Indian languages as in Indo-European languages. Herein lies our difficulty in formulating phonetic laws that are entirely satisfactory to the Indo-Europeanist. For example, *n* becomes *c* in Fox before *i* which is a new morphological element; it remains if the *i* is not such an element. There are some specific grammatical categories in which the law does not work. A study of several related dialects shows that this change also takes place in them, and hence must be very old. At the same time the apparent exceptions have not been explained. Whether they ever will be, is questionable. Yet an Americanist does not object to the formulation of the law as it works in practice. The Indo-Europeanist will object vigorously to such a formulation as it is contrary to his accepted canons. If the canons of Indo-European philologists be accepted, it is quite evident Americanists can not reconstruct the parent languages of American Indian stocks in an entirely satisfactory manner. However, most Americanists are far more interested in observing actual phonetic correspondences and the like between the different dialects of linguistic stocks as they actually occur, than in speculations which from the nature of the case must rest upon rather slim foundations. It may also be noted in this connection that Indo-Europeanists have begun to interest

themselves more with the linguistic problems of historical languages, and less with the remote Indo-European parent language.

Let us return again to the question of the multiplicity of American stocks. As stated above, this is today almost without parallel. However it does not follow that this has always been the case. In Europe we know definitely that Etruscan has been wiped out; but we do not know how many distinct stocks were obliterated by the spread of Indo-European languages. It is entirely possible that many have been so obliterated. If they have, we have then a case quite analogous to the situation in America. But this is merely speculation. The problem may be approached from a different point of view. There is no reason to suppose that the migration from Asia was all from a single stock, in other words, that the differentiation has all been on American soil. Were that the case, in spite of the enormous lapse of time, surely we would be able to find at least one striking morphological trait common to all American Indian languages, for the morphology of a language is its most permanent feature.

Though, as intimated above, we have an apparent multiplicity of stocks which can not be reduced, nevertheless a number have resemblances to each other. An example is Siouan and Muskogean. The question resolves itself to this: Are these resemblances indicative of a common origin so remote that it is no longer possible absolutely to prove it, or are such similarities due to borrowings? To settle the question we must know what may be borrowed. That sounds may be borrowed across extremely divergent linguistic stocks is abundantly proved by the languages of the Northwest coast where we have the condition that languages whose morphology and vocabulary are distinct have practically the same phonetic elements. That vocabulary may be borrowed across linguistic stocks is too well-known to require illustration. That syntax may be borrowed across linguistic stocks is shown by the languages of Mexico where Spanish syntax has patently influenced that of American Indian languages. At this point we may ask a question, namely, can morphological features be borrowed? This is one of the most pressing problems of linguistic science awaiting solution. Unfortunately we have

little material at hand definitely to prove or disprove it. Such as we have tends strongly to establish it. For example it is patent that the post-positions of Wishram (Chinookan stock) are due to the influence of Sahaptian, a distinct though contiguous stock. Similarly, classifiers are common to the Salishan, Wakashan, Chimmesyan, Koluschan, and Skittagetan stocks which are at the same time contiguous. One may suspect, indeed, that the first pair, and similarly the last pair, have differentiated from a common ancestor. Yet at the very best we would have a single striking morphological trait spread throughout three stocks which otherwise have nothing in common in either morphology or vocabulary, but only have resemblances in sounds. It is too great a strain on the imagination to believe that this is wholly the result of chance. If the accepted definition of stock is to remain, namely, a stock consist of one or more languages all of whose sounds, morphology, syntax, and vocabulary genetically have descended from a single ancestor, we must admit at once that this trait which is held in common, is due to borrowing. For the differences in vocabulary and morphology are so enormous that it is inconceivable that the present differences are solely due to later differentiation. The vocabulary and morphology which cannot be explained at present are just as important as the extremely small percentage that can. There are a few other cases in which morphological borrowings between stocks is plausible, but they are entirely too few in number to warrant us at present in applying the principle broadcast. So we have to content ourselves in the meanwhile in pointing out structural resemblances between stocks, such as between Esquimoan and Algonquian, which resemble each other strikingly in their pronominal systems, and to a much less extent in the building up of verbal stems, in the hope that a careful and minute study of all the dialects of such stocks may enable us definitely to affirm whether such traits are due to early differentiation from a common remote ancestor or to comparatively recent borrowings.

It must be admitted that recently there has been a decided tendency among Americanists to consolidate such stocks as

show only a moderate amount of common lexical and morphological resemblances. In some cases, such as Uto-Aztecan, it must be conceded that the burden of proof is now definitely on those who maintain that the two "stocks" are true distinct stocks, and not differentiations from a common ancestor. It is on the other hand equally certain that the genetic connection has not been established with absolute nicety. In the same manner Athapascan, Koluschan, and Skittagetan are almost certainly genetically related. Their morphological resemblances are so numerous and so special that it is incredible that they are due solely to borrowings, and not to genetic relationship. However, the amount of lexical material the three have in common is an exceedingly small percentage of their total vocabulary. The extremely large percentage of the unexplained lexical material forces us to admit that this has been derived from outside sources, and with our present definition of "stock," a purely genetic relationship between the three breaks down. After all, our difficulties all hinge on our definition of "stock," and the proofs necessary to show that one or more languages constitute such a "stock." Though the definition of "stock" given above, may be rigorously correct, the actual application of it would practically obliterate the total number of "stocks" in the world, and we should be worse off than ever. For in that sense, there are few, if any, languages which constitute a stock. In the writer's opinion philologists have taken over biologists' concepts without inquiring whether they are suitable to their own science. "Stock" must be redefined in a way that has some real meaning, and some term or terms invented to cover those larger groups which apparently are only remotely related, which may be related in sounds, morphology, syntax, and vocabulary, but not all combined as a unit. It goes without saying that the nature of the proofs then demanded will be in accordance with our definitions.

To revert to a point brought out above. If the morphology of languages can not be borrowed, with scrupulous nicety we must assume an enormous number of distinct stocks at the very dawn of man, which certainly is not plausible. If on the other

hand, sounds, morphology, syntax, and vocabulary have no innate connection (vide supra) then we would have a series of various borrowings instead of "stock" in its present sense. It may be well however, to state that no matter how "stock" is defined at present, it certainly is not used in that sense alone, but in a more loose way, almost according to the whim of the author.

The most decisive proof that two or more languages belong to the same stock, used in a somewhat free sense, is numerous and detailed resemblances in their structures. A large percentage of vocabulary held in common is a welcome additional proof. The most decisive proof that a single language constitutes a special stock is numerous unique morphological features. No amount of purely lexical resemblances between languages, no matter how far apart geographically, would prove that they belonged to a single stock. For, experience has shown us that vocabulary is very often borrowed in large amounts, and hence is not a good criterion. If the tribes were far apart geographically, that would not preclude the possibility that in prehistoric times they had been in contact, and at that time extensive borrowing had taken place. Another reason why vocabulary is not a good criterion is that the number of words in even distinct stocks that superficially resemble each other is really considerable. An example is Sanskrit (Indo-European stock) *ásan-*, Fox (Algonquian stock) *asen*ⁱ, both meaning "stone." Comparisons of vocabulary are only valuable when we know that the morphology of the languages compared are the same, or at least very similar. Otherwise we should not know whether we were dealing with comparable elements, even if the words in their totality resembled each other. For example, the comparison of the pronoun Avestan *čiš*, Greek τις, Latin *quis*, Oscan *pis*, all meaning "who," is entirely justifiable, because the structure of all four languages is fundamentally the same; and, which is also important, it has been shown that though these words apparently resemble each other only slightly, yet as a matter of fact the correspondence of the various sounds forming these words is precisely what we should expect from our knowledge

of comparative Indo-European phonology. Another example of a case where words of two different stocks superficially resemble each other is Sanskrit *naṣṭa-* "dead," Fox *ne'tōw^{a}* "he kills." It will be recalled that the combination of a sibilant followed by *t* appears as *'t* in Fox. As soon as we note that Sanskrit *naṣṭa-* is composed of the elements *naṣ+ṭa-* and Fox *ne'tōw^{a}* of the elements *ne+'tō+w^{a}*, the comparison ceases to interest us. [The Fox word can, as I think, be reduced still further in analysis, but this only still further emphasizes the point at issue.] We should exercise the same prudence in comparing morphological elements. For example the verbal termination of Latin in the third person singular is *t* which superficially resembles Tsimshian *t*, to say nothing of similar terminations in various Algonquian dialects. Again Greek *μεν*, the verbal termination of the first person plural, has an entirely fortuitous resemblance to Ojibwa *min* in *ni—min*, *ki—min* of the independent mode.

Turning now to the classification of the languages belonging to single stocks,—it must be said that very little work has been done on this important topic in American linguistics. The three stocks of which we have the best knowledge in this respect are Salishan, Siouan, and Algonquian. To a certain extent the classification is arbitrary. We select a number of salient features and base our classification on it. In most cases we have overlappings which are indicative of more than one association. For example, Peoria fundamentally belongs with the Ojibwa division of Central Algonquian languages; at the same time there are certain traits which clearly prove that it has also had an association with the Sauk, Fox, Kickapoo group, also one with Cree; and there are some indications of contact with Delaware-Munsee. Nevertheless in spite of such short comings, we can make classifications which are entirely satisfactory even to the Indo-European philologist. The object of our classifications is to determine the prehistory of the tribes of any given stock. For example, the Abnaki dialects exhibit so many special traits in common with Shawnee, as well as Sauk, Fox, Kickapoo, that it is absolutely certain that in prehistoric times the tribes

speaking these dialects have been in long and intimate contact. In the same way the Central Algonquian dialects are all so closely related, that it is evident that the place of diffusion must have been of limited area. The present geographical distribution of the tribes is insignificant in comparison with the evidence obtained by linguistic procedure. Nevertheless it has its value. It can not be accident that the most divergent Algonquian languages are spoken at the extreme western boundary of the stock.

This last brings us to the question of whether the differentiation of a stock into various dialects is due to evolution without external influence or whether it is due to linguistic shock. To this we reply that every case must be judged on its own merits. Peoria, though spoken today by only a handful of people, has been and is, exposed to far greater linguistic shock than Ojibwa which is spoken by several thousand persons; and, notwithstanding, is in many essential points a far more archaic language than Ojibwa. At the same time its diverse affinities indicate a series of shocks. Similarly, it can hardly be doubted that the divergent character of Aleutian (Esquimauan stock) is due to such shock. It should be candidly admitted that our studies in American linguistics have not yet reached a point where these problems can be answered in a thoroughly satisfactory manner.

It will be remembered that we are not in the position of the Indo-European philologist who can observe what has happened in the differentiation of dialects in a space of several centuries, and thereby draw legitimate inferences as to what happened in the prehistoric period. We also lack good time-measures; so we can not tell how long it has taken such and such a dialect to differentiate itself from its kindred. In this connection it should be stated that the Indian words cited by early travellers and missionaries are so badly recorded, that if the language from which the word is cited, is still extant, ordinarily we can do far better with the words spoken today. The methodical error of using the analogy of Indo-European languages in solving the points at issue, has been shown above. Our guesses from such inferences might be very happy, but they would remain guesses, not proved

facts. Our whole endeavor should be to place American linguistics on a rigid scientific basis, not upon a foundation of guesses. If I have spoken strongly on this point it is because some of the most eminent Americanists apparently desire to do the latter. They wish, without sufficient reserve, to consolidate stocks that apparently resemble each other, and are content to leave it to the next man to prove or disprove their cases. I do not deny that very likely they have made some extremely happy guesses, but I do deny that the *evidence thus far produced*, has been of such a nature as to compel acquiescence in all the results they claim to have obtained.

The opponents of the views here expressed will reply that the proofs demanded are more suitable to the so-called exact sciences than they are to philology; that if such a program be adhered to, we can not possibly hope to accomplish our task, as the languages are rapidly disappearing; that they are interested only in great facts, not minutiae; and that Indo-European philologists concern themselves largely with the latter simply because the great facts of Indo-European philology are known, and hence there is nothing else left for them to busy themselves with. To all of which the following rejoinder may be made: The proofs demanded may possibly be more rigid than those the Indo-Europeanists ordinarily demand, but it should be noted that every year the proofs demanded by the latter are becoming more and more rigorous, so that the disparity is after all being rapidly reduced, and in time doubtless the proofs demanded by philology will be fully comparable to those demanded by the exact sciences; that there is no advantage in erecting a magnificent edifice on such a weak foundation that it may topple over any minute; it is better to do even a little, and that portion well; and lastly, though it may be granted that Indo-Europeanists today are primarily concerned with minutiae, the discoveries of Grimm, Grassmann, Verner, Brugmann, Collitz, Schmidt, Ascoli, de Saussure—all of which were due to more rigorous methods—are of capital importance; and lastly it should be observed that centuries of quasi-scientific study of languages preceded the discovery of the genetic relationship of Indo-European languages,

which of course will be counted as the great fact of Indo-European philology.

To change to a different topic. The study of American Indian languages will show that there is no such thing as superiority in language. They all possess the necessary machinery to express the most complicated ideas. The point is simply that what is grammar in one language may be vocabulary in another, and vice versa. For example there are no prepositions in Algonquian languages, but what we call prepositions are expressed by grammatical processes or special features in vocabulary. Thus "on" will be expressed by the locative case. "To come in" in Fox is *pīti*, "to go out" is *nōwi*. Nor is the language of primitive peoples indicative of low mentality. Thus Fox has but two fractions, one-half and one-quarter. It does not follow at all that the Fox Indians can not conceive of other fractions. As a matter of fact they can. The point is that ordinarily their life is such that there is no necessity for expressing them. I have tested this again and again by asking interpreters how to say, "Give me a third of that pie," and the like. In every case they were able without the slightest hesitation to render the idea, though not the precise words. I mention this simply because Gobineau apparently still has a goodly number of followers and admirers.

In conclusion, the study of American Indian languages is an extremely attractive field for students of general linguistics; and one that as yet is almost virgin soil. By their study the Indo-European specialist will find his scope vastly broadened, especially in the so-called philosophical bearings of his science. The American ethnologist who neglects their study, places himself wholly at the mercy of interpreters; or at the best must rely on the ipse dixit of his wiser colleagues. For these reasons their scientific study should be fostered in every possible way.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Structure of the Vicksburg-Jackson area, Mississippi.* Oliver B. Hopkins. U. S. Geological Survey Bulletin 641–D. Pp. 93–120, with 1 plate. 1916.

The object of this report is to show which of the areas in west-central Mississippi that were examined by the Survey are considered favorable and which unfavorable for the occurrence of oil, to discourage drilling in the unfavorable localities, and thus to aid those interested in making conclusive tests to determine the presence or absence of oil and gas.

All the rocks of the area are sedimentary in origin and are relatively young, the exposed rocks ranging in age from Claiborne (Eocene) to Recent. Of these formations the loess and the Jackson underlie by far the greater part of the area, and the Vicksburg and Catahoula formations and the terrace sand and gravel underlie smaller areas.

The general structure of the Gulf coastal plain is simple. A series of beds slopes gently southward and passes successively deeper and deeper beneath more recent deposits toward the coast. This general dip toward the coast is interrupted by local steepening or flattening and in a few places by a reversal in direction. These irregularities of dip, which are of greatest significance in the accumulation of oil and gas in valuable pools, are well illustrated in the Vicksburg-Jackson area. The geologic structure is represented on a map by contours on the Vicksburg limestone. The possibilities of oil and gas occurring in the area are dicussed and the most promising areas for prospecting are pointed out. R. W. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 785th Meeting was held at the Cosmos Club, March 3, 1917. Vice President HUMPHREYS in the chair; 49 persons present. The minutes of the 784th meeting were read in abstract and approved.

By invitation, Mr. A. H. PFUND presented an illustrated communication on, *The colors of mother-of-pearl.* At the request of the U. S. Bureau of Fisheries the following work was undertaken to ascertain the cause of the iridescence of mother-of-pearl. While this subject has been studied before, the results have been largely of a qualitative nature. By extending the observations into the infra-red region of the spectrum where conditions are much simplified, the author has succeeded in obtaining quantitative measurements which substantiate the explanation of the colors of mother-of-pearl as given by Sir David Brewster.

Under the microscope, a thin section of the shell of a fresh-water mussel is seen to consist of three layers—the inner one being the true mother-of-pearl (nacreous matter). This, in turn, consists of innumerable thin layers of $CaCO_3$ separated by extremely thin layers of organic matter. As the shell grows, successive layers of nacreous matter are deposited on the inside of the shell—each layer projecting slightly beyond the terminal edge of its predecessor. Hence the outside of the nacreous layer will present closely spaced steps or ridges running parallel to the growing edge of the shell. Such a surface structure is identical with that of a diffraction grating, and hence diffraction colors ought to exist. By laying bare the outer surface of the nacreous matter and depositing an opaque layer of silver on it, striking diffraction colors are seen. This surface structure may be studied most readily by means of celluloid casts or replicas of the surface. These replicas show brilliant diffraction colors. Under the microscope the individual lines may be seen and the spacing may be determined. While this is subject to wide variations, the range of spacing observed on the outside of the shell of a fresh-water mussel ranges from 6000 to 25,000 lines per inch. As might be expected, no trace of such a grating-like structure is obtained from the inside of the shell.

As a rule, the diffraction colors are rather inconspicuous, being masked by the blaze of colored light from underlying regions. Since this light is due to reflections from the numerous laminae and since these are parallel and sensibly equi-distant, coloration due to interference might be expected. According to the usual theory, the optical

retardation of two beams reflected from two successive layers is $2\mu e \cos r$ where e is the thickness of the layer, μ the refractive index and r the angle of incidence. If this retardation is a whole number of wave-lengths, constructive interference will take place. Hence maxima of intensity will exist when

$$2\mu e \cos r = \lambda_1,\ 2\lambda_2,\ 3\lambda_3$$

etc., where

$$\lambda_2 = \frac{\lambda_1}{2} \text{ and } \lambda_3 = \frac{\lambda_1}{3}$$

Such maxima were looked for by reflecting white light from the polished surface of nacreous matter and by measuring the intensities in the various spectral regions by means of a spectrometer and vacuum thermo-couple. Since the interference maxima are most widely separated and are sharpest in the infra-red, the observations were carried out in this spectral region. Results obtained from brilliantly colored specimens were entirely in agreement with the above theory, i.e., the wave-lengths of the interference maxima were in the ratio $1 : \frac{1}{2} : \frac{1}{3}$. This quantitative determination proves definitely that the brilliant iridescence of mother-of-pearl is due to interference.

By determining the refractive index of the nacreous matter, it was found possible to determine the actual thickness of the laminae. The results, which differed somewhat for different specimens, showed that the thickness is of the order 0.4–0.6μ.

Discussion. The paper was discussed by Messrs. SOSMAN and WRIGHT. Mr. Pfund was of the opinion that the number of layers of material in the shells examined was too great to correspond with the number of days or with the number of tides occurring during the life of the shell.

Mr. W. F. MEGGERS then presented an illustrated paper on *Interference measurements of wave-lengths, and infra-red spectrum photography.* Interference measurements of wave-lengths in the portion of the iron arc spectrum in which the International Secondary standards exist (3233 A to 6750 A) have been made at the Bureau of Standards. The wave-lengths of about 320 lines were compared with those of the 85 secondary standards by the interferometer method of Fabry and Pérot. The average interval between standards was thus reduced from 40 A to 8 A, making accurate interpolation easier. Whereas 86 per cent of the secondary standards have intensities 4 to 6 inclusive, only 47 per cent of the new lines have these intensities, the remainder being distributed among fainter and stronger lines. This makes it possible to photograph sufficient standards with a wider latitude of exposure.

Similar measurements were made in the spectra of the rare gases, helium, neon, argon, krypton, and xenon. The wave-lengths were compared with the fundamental spectroscopic standard (wave-length of red radiation from cadmium = 6438.4696 A). The measurements in the neon spectrum show differences in the numbers of waves per

centimeter (frequency differences) to be constant to 1 part in several millions.

An extensive application of these standardized wave-lengths has been made to an investigation of spectra in the red and adjacent infra-red regions. The arc spectra of 20 of the chemical elements have been photographed from 6000 A to 9000 A and beyond. The photographs were made in the first order spectrum of a concave grating of 640 cm. radius. Ordinary photographic plates stained in dicyanin solution were used and found to be quite sensitive to the long waves. Wave-length measurements on the international scale have been made in these spectra and most of the frequency differences in the spectra of the alkali metals are shown to be constant to 1 part in several hundred thousand of the wave number.

Mr. F. E. Fowle presented an illustrated paper on *Spectroscopic field light.* When a spectrum is formed the energy observed at any wave-length is not simply what is proper to that wave-length but it is diminished by a portion scattered into other parts of the spectrum

TABLE 1

Spectroscopic Field Light

1. Wave-length in μ	1.8	5.7	7.0	8.0	10.0	12.0	14.0	17.5
2. Deviation in minutes	0	10	15	20	30	45	60	100
3. Quartz transmits	85,000	206	117	85	50	27	17	8
4. Ditto corrected	100,000	242	141	100	59	30	20	10
5. Total field light		244	146	107	66	33	22	11
6. Black-body radiation	100,000	5000	1800	1000	400	140	65	20
7. Nernst-lamp radiation	100,000	5000	1800	1000	400	140	50	2

and increased by portions scattered in from other regions. In measurements in long-wave spectra this scattered radiation or field light may become very important and troublesome. Rock-salt prismatic energy curves were made of the radiation from a Nernst lamp with a half-centimeter thick quartz plate inserted between the energy source and the silt of the spectroscope. The quartz is nearly transparent for light waves less than 4μ in length, and opaque for those longer. The resulting energy curves consisted of two parts of quite different significance: 1st, a nearly symmetrical sharp maximum, the energy curve of the source to 4μ; 2nd, beyond this the energy curve of the light scattered from this region into that for which quartz is opaque. This central maximum with a wing-like appendage on each side was assumed to represent closely the energy curve of a monochromatic line with the radiation scattered to each side in the spectrum. This curve was used to compute the energy scattered into and away from each region of the spectrum. A summary of the results is given in Table 1 in which the captions in the first column have the following significance:

(1) Wave-lengths in millionths of a meter μ; (2) Deviation differences in minutes of arc, 15° rock-salt spectrum, zero deviation at 1.8μ;

(3) Nernst-lamp spectrum observed through a ½ cm. quartz plate; (4) Ditto corrected to allow for the reflections from the surfaces of the quartz plate; nearly equivalent to ordinates of the energy curve of a monochromatic line with the energy scattered to the long-wave side; (5) Total field light which would be expected in the spectrum of a Nernst lamp when the intensity of the latter is 100,000 at 1.8μ (see line 7); (6) Computed relative intensities in black-body spectrum of a body at 2200°K radiating to one at 300°K; (7) Corrected observed intensities of Nernst-lamp spectrum approximating the conditions of line 6 but differing for wave-lengths greater than 12μ because of the increasing absorption of energy in the rock-salt plate closing the vacuum bolometer case and in the prism, and the decreasing absorption by the lamp-blacked surface of the bolometer strip. The intensity of the scattered energy is really very small in any given region although the total amount lost from any region amounts to about 3 per cent of the true intensity of the region. At an angle of 10 minutes from the direction in which the beam is normally reflected the intensity of the scattered energy is only about 0.2 of 1 per cent of that of the main image. It will be noted in the table that at 17.5μ the field light is over five times the true-energy in the lamp spectrum. From a badly tarnished mirror the increase in scattered light is relatively greater for greater deviations from the main image. (This paper will probably appear in the Astrophysical Journal.)

Discussion. Mr. C. G. ABBOT commented on the large amount of work necessary to obtain the results presented.

Informal communications. Mr. C. G. ABBOT spoke of difficulties in producing satisfactory damping in galvanometers, and Mr. W. P. WHITE mentioned a variation in damping with the magnitude of the deflection, that would seem to be due to the damping effect of the air in the clearance space between the armature and the pole pieces.

DONALD H. SWEET, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 567th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday March 10, 1917; called to order by President HAY at 8 p.m.; 45 persons in attendance.

On recommendation of the Council, Mrs. L. O. HOWARD and Dr. MARTHA BREWER LYON were elected to active membership.

Under the heading book notices, brief notes, etc., Dr. H. M. SMITH exhibited a manuscript and hand-illustrated book dealing with beetles. It was about 60 years old. Dr. Smith presented it to Dr. L. O. Howard. Prof. W. P. HAY presented some notes on the flying squirrels of this vicinity with observations on their habits and behavior as pets. Dr. H. E. AMES called attention to a newspaper clipping recording the flight of two tagged ducks a distance of 2000 miles in about 60 hours. He sought verification of the statement.

The regular program consisted of two communications:

M. W. Lyon, Jr.: *Precipitins.* Dr. Lyon described an antibeef-serum he had lately prepared, and set up a series of test tubes containing dilutions of beef, sheep, hog, and human serums. He demonstrated the action of the antibeef-serum on these, the specific precipitation when added to the diluted beef serum, the group precipitation with diluted sheep serum, and the non-precipitation with diluted hog and human serums. He mentioned briefly the history and theory of precipitating serums and explained their use in identifying suspected animal proteins and in showing the blood relations of various animals. In discussing this communication A. H. Jennings explained how he had made use of the precipitin reaction in determining the kinds of animals bitten by biting flies. Dr. George W. Field and H. F. Taylor also took part in the discussion.

William Palmer: *Porpoises and steamers.* Mr. Palmer commented on the frequency with which porpoises are found about the bows of steamers and advanced explanations as to their presence there and as to their methods of progression. His communication was illustrated by diagrams and lantern views of porpoises and other cetaceans. It was discussed by Dr. H. E. Ames.

M. W. Lyon, Jr., *Recording Secretary.*

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Thursday, April 19: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

1. LANGMUIR: *The constitution of liquids* (illustrated).

Saturday, April 21: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, April 25: The Geological Society, at the Cosmos Club, at 8 p.m.

Tuesday, May 1: The Botanical Society, at the Cosmos Club, at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh day of each month.

CONTENTS

Original Papers

	Page
Physical Chemistry.—A convenient form of autoclave. George W. Morey.	[illegible]
Mineralogy.—Leverrierite from Colorado. Esper S. Larsen and Edgar T. Wherry	208
Medical Zoology.—The carriage of disease by insects. L. O. Howard.	[illegible]
Ethnology.—Remarks on American Indian languages, a study in method. Truman Michelson	[illegible]

Abstracts

Geology	[illegible]

Proceedings

The Philosophical Society of Washington	[illegible]
The Biological Society of Washington	[illegible]

Vol. VII

May 4, 1917

No. 9

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. VII MAY 4, 1917 No. 9

GEOPHYSICS.—*Live aa lava at Kilauea.* T. A. JAGGAR, JR., Hawaiian Volcano Observatory. (Communicated by Arthur L. Day.)

In a paper yet unpublished[1] the writer maintains, from measurement and experiment, that the Kilauea lava column is twofold, a main semisolid incandescent body or "bench magma," filling the Halemaumau pit shaft from side to side for an unknown depth, and a minor shallow liquid lava body or "lake magma," which circulates through several small vertical shafts 10 to 30 metres in diameter. These act as conduits and sinkholes below a saucer 8 to 15 metres deep in the bench magma column, this being the well known "lava lake." The lake magma exhibits a convectional circulation, more rapid than that of the bench magma. It builds the bench magma by overflow and bottom accretion during rising, and uncovers its bottom partially by more rapid subsidence during sinking. The border benches and islands are of crusted protuberant bench magma and are incandescent and mobile within. In the bench magma, under overflooding and its opposite (unloading by the sinking away of the lake), a slow circulation is discernible, which resembles isostatic adjustment in its mechanism.

Under an adjustment of this kind, after subsidence prior to the equinoctial low level of March, 1917, when the lake bottom had been unloaded by a sinking of the lake magma, some 12

[1] Sent to the American Journal of Science.

metres in excess of the sinking of the bench magma (lake bottom), a towering uptilted bench crag on the east side of the interior of Halemaumau subsided 9 metres in the course of twelve hours, and opposite to it in the lake a low flat island rose 12 metres, becoming in one night a towering flat-topped, steep-sided mass. Flow from beneath the crag was compensated by upflow beneath the island, the distortion affecting, not the lava lake, but the lake bottom. At that time the lake near this island was possibly not more than 5 metres deep, proved by subsequent uncovering of the bottom locally. Simultaneously other parts of the bench subsided and island features rose, corroborating by survey the equilibrium relation shown by this extraordinary east island.

Rising began on March 20, 1917, and on March 24 the writer crossed the now solid arch of crust which had formed by congelation and overflow between the east shore of the lake and the island, and examined the base of this monolith. It proved to be aa or block lava. This is the first identification of actual aa under formative conditions in Halemaumau pit known to the writer, though aa exists as rare flows on the floor of the greater crater of Kilauea. It occurs also as graduation forms of the dominant pahoehoe, notably on the west lip of overflow, or rampart of Halemaumau, last actively overflowing when the lava in the pit reached its highest and receded in 1894.

This east island has been figured.[2] The depression of the lake below the rim of the pit at the time of the sudden lift of the island was about 29 metres. The flat elongate islet from which it arose had been 66 metres long on February 14, but only the southern half of this was raised into the new tabular mass, the remainder forming a tumble of pinnacles which extended it northward. The tabular elevation was 25 metres across the top and subcircular. The top was bounded by a vertical cliff 3 metres deep showing horizontal layers of pahoehoe made by lake flooding during fluctuations of the lake level, while the island was low and at or near the lake level. Below was the

[2] Bull. Hawaiian Volc. Obs., Feb., 1917.

aa pedestal sloping outward steeply, scored vertically in places, 9 metres high above lake level, and showing a rough scaly appearance of greenish black color. At lake level its diameter was approximately 45 metres.

The flat islet from which this mass was raised was first noticed February 8, 1917, after 9 metres of subsidence of the lake from its highest level of February 1. The island then appeared as a shoal 60 metres out from the shore in the northern part of the lake, and was supposed to be the product of collapse of a shore point of the eastern bench, which had in turn emerged first as an islet in November, 1916. The locus of the final tabular mass was farther south than either of these.

There is little to be said at this time about the lithology of the aa. It is a heavy block lava which consists of the usual complete, scoriaceous, vesicular units in the talus 5 to 30 cm. in diameter, showing no fracture surfaces, and of reddish or greenish brown color. In the wall the rock is in places grooved vertically like scraped wax, a steel-grey rough substance, and overhanging drip bodies are hard, scoriaceous and quite like the block units. The material is nowhere ropy or membranous like pahoehoe, and has not the slightest resemblance to the crusts and overflows of the lake. It is very similar to the aa flow which was ejected from Mauna Loa in 1916.[3]

STRATIGRAPHY.—*Tongue, a new stratigraphic term, with illustrations from the Mississippi Cretaceous.*[1] LLOYD WILLIAM STEPHENSON, Geological Survey.

The stratigrapher is at times confronted with the problem of adequately treating certain tongue-like extensions of one formation into contemporaneous deposits of different lithologic character and belonging to another formation.

A simple hypothetical case is diagrammatically shown in figure 1.

[3] Amer. Journ. Sci., March, 1917.

[1] Published with the permission of the Director of the United States Geological Survey, and of the Director of the Mississippi State Geological Survey.

Sedimentation began in this assumed area with the deposition of sand, formation *A*; later clay, the base of formation *B*, began to be deposited on the left and as far to the right as *a*, while sand was still accumulating on the extreme right; as time proceeded the sand-forming conditions shifted to the left and upward as far as *b*, followed by a shifting of the clay forming conditions to the right entirely across the area, the latter continuing until all of formation *B* had been produced. The shifting of the two types of sedimentation resulted in the formation

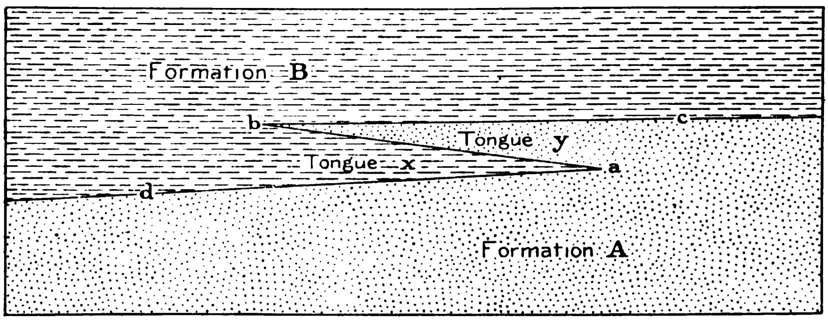

Fig. 1. Diagram showing the relation of tongues to formations.

of a body of clay *x* projecting into the sand formation *A*, and a corresponding body of sand *y* projecting into the clay formation *B*.

So long as such features are relatively small, that is, less than 4 or 5 feet thick and less than a mile long, they can, as a rule, be disregarded in geologic mapping without seriously distorting the facts. There is also no difficulty in their treatment when the area to be mapped does not include the places of junction of the projections with the main formations, for then the features can be classed as lentils, members, or even formations, without apparent inconsistency. But when the projections attain 25 to 200 feet or more in thickness and from a few to many miles in length, and the areas under consideration are large enough to show the connection of the projections with the main formations, the usual methods of mapping compel an arbitrary or even false representation of the facts.

In the hypothetical case represented by figure 1, the boundary between formations *A* and *B* would have to be represented on a geological map in part by drawing an arbitrary line from the outcrop of the point *a* to some such point as *c* on the outcrop of the contact between the main bodies of sand and clay, treating *y* as a sand member or lentil in formation *B*; or by drawing an arbitrary line from *b* to *d* and treating *x* as a clay member or lentil in formation *A*. In either case the true relations would be inadequately represented.

It is therefore proposed that such features as *x* and *y* in figure 1 be designated "tongues" and that for convenience of treatment they be given geographic names correlative in rank in geologic nomenclature with such terms as "member" and "lentil." In geologic mapping it is proposed to extend the color or pattern representing the main formation to include the area of outcrop of the tongue.

Especial emphasis should be laid on the fact that a tongue is not a member nor a lentil, either one of which differs lithologically from the typical material composing the formation of which it forms a part, but is lithologically identical with, or closely similar to, the formation. The term carries with it the implication of connection at one end with the main formation, though the tongue is underlain and overlain by materials lithologically different, and belonging to another or other formations. Theoretically the tongue may end distally in a point; more often perhaps the terminus presents a series of minor tongues; or the material composing the tongue may merge more or less gradually into the kind of material composing the formation into which the tongue projects.

In the present stage of development of the subject it is not possible to set definite dimensional limits to serve as a guide in determining the features to which the term tongue shall be applied. Large-scale maps admit of representing relatively small tongues, that is tongues only a few miles long and a few feet thick. On the other hand a tongue-like projection as large or even larger than some of the units to which the terms member and formation are now applied, may be appropriately called a tongue,

provided the main formation of which it forms a part is relatively much larger. It would seem desirable, however, that the term should be restricted to projections less than half as thick as the main formation, for any mass that is of greater thickness could reasonably be regarded as the continuation of the formation itself, and as such would require no additional name. In the particular examples in Mississippi, to be described on subsequent pages, each of the two tongues, the Mooreville tongue of the Selma chalk and the Tupelo tongue of the Coffee sand member (see pp. 247–8), are about 20 miles long, one is approximately 200 feet thick and the other 100 feet thick. The Oktibbeha tongue of the Selma chalk (p. 249) is between 50 and 60 miles long and only 25 to 50 feet thick; this seems like a rather extreme length for a subordinate geologic feature, but when this tongue is compared with the main formation, the Selma chalk, which is at least 350 miles long, and where most fully developed nearly a thousand feet thick, the tongue is a relatively small feature.

The distance to which a tongue maintains its distinguishing lithologic character down the dip away from the area of outcrop need scarcely be considered in determining what features shall be classed as tongues, any more than the same dimension is considered with reference to lentils, members, or formations; for although changes in conditions of sedimentation oceanward from a shoreline are always interesting in connection with problems relating to geologic processes and geologic history, such factors need not as a rule be taken into account in areal mapping and geologic nomenclature.

The method here proposed for treating tongue-like projections of formations has already met the approval of the geologists with whom the writer has consulted, for those who have had extensive experience in geologic mapping recognize that such features exist, and appreciate the difficulties attendant upon their treatment according to the usual methods of presentation.

It seems desirable to present several concrete examples of the features under consideration to serve in a sense as types for

reference. Four tongues have been differentiated by the writer in the Cretaceous deposits of the eastern Gulf region, three in Mississippi, and one in Alabama, each large enough for representation even on a one to one million scale map. The three tongues in Mississippi and the major formations and members with which they are closely interrelated are shown in figure 2.

As the mention of these examples is in effect the introduction of new geologic names, brief definitions are added. More comprehensive definitions and descriptions will appear in a forthcoming report on the stratigraphy of the Cretaceous deposits of Mississippi.

Mooreville tongue of Selma chalk. The basal part of the Selma chalk of east-central Mississippi is represented in northern Mississippi by contemporaneous non-chalky strata, chiefly sands with subordinate amounts of clay, belonging to the Coffee sand member of the Eutaw. The passage from chalk to sand takes place in western Itawamba and eastern Lee Counties, and is accomplished by the intertongueing of chalk and sand, and by the merging of the one kind of deposit into the other. Two conspicuous tongues are developed, one of impure chalk, here named the Mooreville tongue, which projects from the basal part of the chalk northward into the Eutaw type of deposits, and another of sand, the Tupelo tongue, which extends southward from the Coffee sand member of the Eutaw formation into the chalk, the Mooreville tongue below interlocking with the Tupelo tongue above. These relations are diagrammatically shown in figure 2.

The material composing the Mooreville tongue consists chiefly of argillaceous chalk and shaly chalky clay or marl. An exposure along the Fulton road, $\frac{3}{4}$ mile west of Mooreville, Lee County, may be regarded as typical. Here the top of the hill is capped with about 8 feet of red weathered sand of the Tupelo tongue of the Coffee sand, beneath which in the road cut is about 20 feet of dark shaly clay from which most of the lime has been dissolved and removed by percolating waters, followed in a deep gully south of the road by about 20 feet of greenish-gray shaly chalky clay, containing small crystals of gypsum in the joint

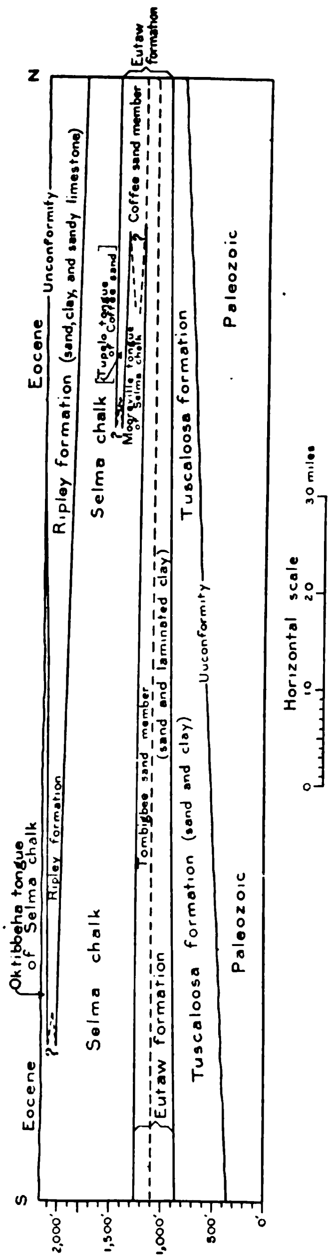

Fig. 2. Diagrammatic vertical longitudinal (parallel to strike) north-south section showing the relation of features described as "tongues" to major formations in Mississippi.

cracks. The thickness of the Mooreville tongue as shown by the log of a well near Tupelo is 215 feet.

The Mooreville tongue finds its physiographic expression in a subdued topography which is in contrast to the hilly aspect of both the area to the west underlain by the Tupelo tongue of the Coffee sand, and the area to the east underlain by the main body of the Eutaw formation.

Tupelo tongue of Coffee sand member The Tupelo tongue of the Coffee sand member of the Eutaw is a body of dark gray, chiefly massive, calcareous, glauconitic sand extending southward from the Coffee sand of northern Lee County into the main body of the Selma chalk, being underlain by a corresponding tongue of chalk, the Mooreville tongue, which extends northward from the basal part of the Selma. The Mooreville tongue loses its identity by merging into—or minor intertonguing with—the Coffee sand type of deposit, in central and northern Lee County, while the Tupelo tongue loses its identity by merging into—or minor intertonguing with—the chalk in southern

Lee County. These relations are graphically shown in figure 2. An exposure in an abandoned portion of the Fulton road, 1½ miles east of Tupelo, is considered the type section (Table 1), though the town of Tupelo is itself underlain by the sand beneath a relatively thin covering of Pleistocene terrace deposits.

TABLE 1

SECTION IN AN ABANDONED PORTION OF THE FULTON ROAD, 1½ MILES EAST OF TUPELO

	Feet
Eutaw formation (Tupelo tongue of Coffee sand member)	
Weathered massive reddish ferruginous marine sand, grading downward into yellowish-green massive slightly glauconitic sand	30
Massive gray, more or less calcerous, glauconitic sand, with several widely separated ledges of calcerous sandstone. *Gryphaea vesicularis* (Lamarck) var., abundant in a layer 15 to 25 feet below the top, and *Exogyra ponderosa* Roemer and *Gryphaea vesicularis* (Lamarck) var., fairly abundant in a layer 10 feet below the top	50

The thickness of the Tupelo tongue as shown by the logs of wells at and near Tupelo is 100 feet.

The Tupelo tongue is physiographically expressed by the hills in its area of outcrop, which contrast with the subdued topography of both the area to the west underlain by the Selma chalk, and the area to the east underlain by the Mooreville tongue of the Selma.

Oktibbeha tongue of Selma chalk. A long thin tongue of chalk projects from the extreme top of the Selma chalk in northwestern Noxubee County, northward through the counties of Oktibbeha, Clay, and Chickasaw, conformably above the southward extending nonchalky sands and clays of the Ripley formation (see fig. 2). This chalk forms the uppermost part of the Upper Cretaceous and is unconformably overlain by strata of Midway age (Eocene). The chalk is typically exposed in gul-

lies on the campus of the Agricultural and Mechanical College near Starkville; on the Mayhew road, $1\frac{3}{4}$ miles east of Starkville; and along the Osborn road within 3 miles northeast of Starkville, Oktibbeha County. The exact thickness of the tongue has not been determined but probably nowhere exceeds 50 feet. In Table 2 is a description of the section exposed in the Mayhew road.

TABLE 2

SECTION IN MAYHEW ROAD, $1\frac{3}{4}$ MILES EAST OF STARKVILLE

	Feet
Selma chalk (Oktibbeha tongue):	
Moderately sandy and argillaceous,chalky limestone with many fossils	26
Ripley formation:	
Gray, finely micaceous, somewhat calcareous sand, with a few slightly indurated ledges	20
Moderately sandy, very calcerous clay	4

Prairie Bluff tongue of Selma chalk. A tongue of chalk in Alabama, similar to and contemporaneous with the Oktibbeha tongue of Mississippi, extends eastward from the main body of the Selma chalk in Marengo County nearly through Wilcox County, south of and parallel to the westward extending extremity of the Ripley formation of Alabama. This tongue appears to be separated from the underlying Ripley sand by an unconformity, probably representing only a relatively short time interval. The term Prairie Bluff is applied to this tongue, being a revival of a name first used in a geologic sense by Winchell[2] in 1857, for the chalk or "limestone" exposed in Prairie Bluff, Wilcox County, Alabama.

[2] WINCHELL, A. Proc. Amer. Assoc. Adv. Sci., 10^2: 84, 90. 1857.

BOTANY.—*Taxonomic botany and the Washington botanist.*[1]
A. S. HITCHCOCK, Bureau of Plant Industry.

Of the 162 members of this society practically all are professional botanists or are professionally interested in some phase of botany. Furthermore most of the members are in the Government service. We are all aware that scientists in the employ of the Government are engaged upon special problems. They become specialists and all their official time is spent upon investigations directly connected with their specialty. Some members, particularly the older ones, have entered the service from professorships, but a large number have become members of this society soon after being graduated from College. The botanist who teaches is compelled by circumstances to keep in touch with the advance along all lines of botanical research. The same is true of many botanists connected with experiment stations, and may be true of a few botanists unconnected with the two classes of institutions mentioned. But how many members of this society are so situated that in the discharge of their official duties they are brought in contact with all the chief lines of botanical science? The number is indeed small. A teacher may specialize, but a specialist rarely retains his grasp upon general botany. Some of us were teachers before entering the Government service, but I venture to say that few of us have retained the impetus acquired from previous training in general botany. The condition then is this: We are a society of specialists and a large proportion of us are young men who from choice or necessity have entered upon a specialty soon after leaving college, often before we have had the time to lay a foundation in general botany broader than that given by comparatively elementary courses.

It is not my purpose to discuss the merits of general versus special training. We must accept conditions as they are and better them if we can. I am sure that all of us welcome opportunities for familiarizing ourselves with the work which is being

[1] Address of the retiring president of the Botanical Society of Washington, delivered March 4, 1917.

done in branches of botany other than our specialties. We read botanical journals; we attend the meetings of this society and of the national botanical societies; we exchange ideas with our botanical neighbors and visitors. In these ways we absorb fragments of botanical information and in a desultory manner keep in touch with the progress of botanical research. There is another opportunity for broadening our outlook, one which yields enjoyment as well as botanical profit, namely, the study of systematic botany.

Therefore to-night I wish to present for your consideration a few remarks on the advantages of taxonomic botany as an avocation. I shall address these remarks particularly to the younger men, though I hope the older members may be cajoled into giving an attentive and sympathetic ear. I hope to show, first, that there is a favorable opportunity here in Washington for the study of systematic or taxonomic botany and, second, that such a study may be a distinct advantage to those who will take the time for its pursuit.

Few of you who are not engaged officially in systematic work are likely to have the time or the inclination to undertake an elaborate monograph of a difficult group of plants. We may therefore dismiss this phase of the subject from consideration. The field of study to which I wish particularly to call your attention is that of the local flora. Here is an opportunity right at our door, fully available during the growing season, partly available even in winter. The student may grasp much or little, as circumstances permit. Recently the study of the local flora has received an impetus through the efforts of several of you who have undertaken to study particular groups and have devised keys to the genera and species of the flowering plants found in the vicinity of Washington. The standard manuals of the flora of the northeastern states include this region. The flora itself has been studied in a more or less desultory manner by several botanists through several decades. The student therefore will find the way fairly well cleared for him. It will be comparatively easy for him to become familiar with the flora, at least in a general way. Except in complex

groups he will be able to coordinate the plants with their botanical names. The pioneer work has been done, but many details remain to be elaborated.

So much for the opportunity; now for the benefits. The advantages may be divided conveniently into two classes, humanitarian and technical. I need say little concerning the humanitarian side of the subject. Those for whom a walk in the woods is a pleasure will accept with little argument the statement that the pleasure is greatly enhanced by a "speaking acquaintance" with the plants they see. They meet plants as friends, they call them by name, they glory in their beauty, they sympathize with their misfortunes and accidents. The stranger in the plant community is greeted with joy and its presence is chronicled in the annals of the excursion as an event of importance. A knowledge of plants turns a Sunday afternoon's aimless meandering into a purposeful quest through Nature's laboratory, resulting in a broadened outlook, a keener enjoyment, and incidentally an increased knowledge of plants.

Let us now turn to the other side, the technical training afforded by studies in systematic botany. All will readily admit the desirability of being familiar with the more important families of plants. A knowledge of family characters brings a concomitant familiarity with the important genera and species. It is a distinct advantage to a botanist, be he physiologist, anatomist, or mycologist, to know the botanical relationships of the economic plants with which he comes in contact and to recognize the family to which belong the common weeds, wild flowers, and cultivated ornamentals. To see a systematist who does not understand the meaning of a Mendelian ratio or the significance of 15 chromosomes, is disconcerting; to see a physiologist who can not distinguish an oak from a maple, or knows not the family relation of cotton and hollyhock, is appalling.

A study of the local flora will afford opportunities for the self-training we are now about to consider. One should go further than merely to find the accepted names of plants. He should do constructive work; he should carry on critical investigations. For this there is abundant opportunity. Every

complex genus in our flora needs further elaboration. Among such may be mentioned Aster, Carex, Cyperus, Meibomia, Panicum, Quercus, Rosa, Rubus, and Viola. There are many others. In fact there is scarcely a genus of the flora that is satisfactorily known; scarcely a genus but which on critical investigation presents surprises. Species have been misunderstood; strange species from the outside are found in our midst; even distinct undescribed species are not rarely brought to view. The genus Panicum has received much attention for many years, but every fresh investigation brings new and interesting facts to light. Botanists may turn to good account intermittent field trips by the accumulation of data however isolated or disconnected. There is a high probability that interesting facts concerning almost any of our species await discovery. These facts may have an important taxonomic bearing. Few of us can recognize in fruit all the species that we know in flower. More should be brought to light about the winter condition of our herbaceous perennials. What are their underground parts and how do they propagate? How many of our annuals are winter annuals and what is their winter phase? A study of the trees, shrubs, and woody vines in winter is a prolific source of enjoyment and botanical profit. Only recently was it discovered that in Danthonia cleistogamous spikelets are produced at the base of the foliage leaf-sheaths, these cleistogenes being strikingly different from the spikelets on the ordinary inflorescence. Yet species of Danthonia have been under observation a hundred years and one species, *D. spicata*, is very common throughout this region, its curly tufts to be seen on every sterile hill. The chickadees showed us that the spikelets of *Panicum clandestinum* hidden in the sheaths are fertile and hence edible, while those of the exserted panicles are sterile and hence have no attraction for them. A keen observer can scarcely walk for an hour through field or forest without gleaning important information for his fellow workers. The accumulation of unrelated data of this kind not only trains the person making the observations but, when placed upon record, also becomes of service to botanical science. The willing worker will find

abundant material close at hand to which he may devote his spare time and from which he may derive the training he seeks. Science will be the gainer by the facts discovered and arranged; the worker will be the gainer by the training and experience.

How the training and experience may be most advantageously obtained will now be examined in detail. Let us suppose that one of us has become interested in the genus Aster as represented in our flora. Here is an opportunity for a genuine taxonomic elaboration of a difficult group, but limited in such a way that all the material may be studied in a fresh as well as in a preserved condition. Collections of herbarium material will of course be secured, because a direct comparison of species is thus made possible. But the worker has the distinct advantage of being able at intervals to consult the living plants and thus to test the conclusions drawn from the herbarium. First he must become familiar with the plants he wishes to study. He will attempt to identify the species by one or more of the standard manuals. Some of the species will fall in place easily; others will be referred with doubt. At first he will be inclined to assume that the author he is following knows all about the genus Aster and has all our species properly placed under the names given in the manual. He may even attempt to distort a description in order that it may fit a given plant. All of us who have used manuals have passed through this stage. But to do really constructive work an investigator must free himself from the shackles of tradition, from the repressing weight of authority. So long as the student accepts without question statements in manuals, or elsewhere for that matter, which do not appear to accord with the facts as he sees them, so long will he be impeded in his efforts, so long will he fail to reach that freedom of mind necessary for unbiased investigation. Nothing has so hampered progress as the inertia of authority. This does not mean that we should not utilize to the fullest extent the results of the work of others. It does mean that we should meet problems with an unprejudiced judgment, unbiased by tradition, unhampered by authority.

Returning to our investigator of asters, his constructive work begins when he has familiarized himself with the work of others, knows the species or groups of species in a general way, and begins to look at things as they are rather than at things as others say they are. In breaking away from tradition he should be careful to maintain an attitude of fairness toward those leaders of thought who have been responsible for the dominance of the concepts he rejects. We all make mistakes and our reputation is affected by their number and character. But to assume that the statements in a manual are free from error in details, and, on the discovery of small errors, to condemn the author and reject his authority, is unfair. If a botanist in whom we have confidence makes a statement concerning Aster which we know to be based upon carefully weighed evidence, we are fully justified in assuming the probable truth of the statement. Nevertheless our worker should not hesitate to verify the statement if it concerns that upon which he wishes to form an independent judgment. While authority may through error turn the channels of thought for a time in the wrong direction, yet the more common hampering effect of authority is an unconscious influence of the leader upon the follower. That is, the follower gives to the casual or ill-considered statements of the leader, the same weight that he does to those carefully thought out. Few leaders fully realize with what unquestioning faith their every statement is received by their loyal followers. Certain statements botanical authorities can make with confidence. Other statements they make casually or with reservations, not always being careful to distinguish by the form of the statement the two mental attitudes.

Having burst the shackles of authority, our friend should make rapid progress with his asters. The exhilarating freedom is delightful but not infrequently seductive. He has now become a specialist. He feels, and with good reason, that he knows more about the District asters than anyone else. He should, however, keep clearly in mind the danger confronting every specialist—the danger of substituting the authority of self for the authority of his predecessors. The tendency to

make definite decisions as to the relations of facts discovered is a natural one but may constitute a real menace in the future. Having made a public statement as to the validity of a species he may be reluctant to make a public retraction, even though the evidence seems to require this. Rather than make a retraction he seeks for facts to support the original statement. He welcomes such facts and magnifies their importance. Facts tending to controvert the statement are excused or brushed aside or given a minimum weight. He may enter that category of scientists who assume the correctness of a theory and subsequently spend their time hunting for facts which will support it. If the investigator can guard against this danger he has accomplished much. If he can look upon his own work and his own published statements with the same detached interest and the same unbiased judgment that he does upon the work of others, he has assumed the truly scientific attitude. One does not like to be accused of drawing hasty conclusions. One does not like to make a statement one day only to deny or modify it the next. Nevertheless if he preserve an open mind toward investigation, the worker will, I believe, find it necessary to change his opinion as the facts accumulate. To accomplish results of the highest value he must establish an hypothesis as a basis for the arrangement of his facts, but this should remain tentative and elastic. The specialist on Aster examines individuals, but the facts thus obtained must be classified and arranged if they are to be of taxonomic use. He soon establishes in his imagination a series of groups which biologists call species. To these groups he attempts to refer all the individuals he meets. It is not advisable to defer the establishment of the specific concepts until the end of his investigations. Theoretically this may be the best procedure, but practically the worker can scarcely avoid forming preliminary ideas of specific limitations. These preliminary concepts should form a temporary hypothesis, to be changed from time to time as the work progresses. The great majority of investigators are able to keep their mental attitude in a responsive condition up to the time they first publish the results of their work. It

is at this point that the danger from crystalization occurs—the danger that the mobile mental attitude will harden. After publication the worker may feel called upon to defend his statements against the attack of critics. What before was a detached investigation of facts becomes an effort at personal vindication. All these troubles might be avoided by deferring publication. Indefinite delay, however, is not advisable. Actually to finish an investigation before results are published would usually mean no publication. The author should be unhampered but should choose the happy mean between "rushing into print" with half-prepared preliminary notes, and indefinitely delaying publication till a perfect monograph may be produced. It is of course desirable to ascertain before publication all the facts bearing upon a subject but sometimes our hands are forced in such matters. Publication on a given subject may call for a statement concerning something which has not been thoroughly investigated. All of which emphasizes two points already mentioned, that equal weight should not be given to all the statements of an author, and that the author himself should correct his own errors as freely as he corrects those of others.

Our worker with Aster will have the opportunity for training in another field, that of taxonomic judgment. It is well that every scientist should have training in the two methods of establishing facts, by experiment and by repeated observations. Most facts in physical science are established by experiment; most facts in descriptive biology are established by repeated observations. In practice a taxonomist is called upon to classify individuals into species, and species into genera. A species is not a law or a fact that can be proved by experiment. It is a taxonomic idea which can be established only by a great repetition of observations. Our classification is based upon the evolutionary hypothesis that all living organisms are descended from other somewhat different organisms of the past. Setting aside the differences of opinion as to the independent origin of the larger groups, it follows that all organisms, at least of family groups, are probably genetically connected. Their lines of

descent are not known to us. We are able to observe, not the complete connecting lines as represented by an infinite number of individuals, but only a cross section of the lines as represented by the organisms of the present. The task of the taxonomist is to form an opinion as to the probable relationships of the individuals. This taxonomic judgment is based upon and is developed by experience. In many cases the evolution has proceeded so far that a group of individuals has become distinctly separated genetically from its allies. The individuals of this group interbreed freely and form a coherent aggregation to which biologists have applied the term species. If all organisms had, through the process of evolution and the elimination of intermediates, become definitely segregated into these distinct coherent groups, the task of the taxonomist would be greatly simplified. The species being definite, he would be obliged only to offer guesses or opinions as to the relations of the species, and to classify them into groups. However, evolution is still going on, new species are forming, and old species are becoming extinct. We see, as it were, a still scene from a series of moving pictures representing the development of organisms. In complex groups such as Aster the lines of descent are still nearly parallel. They are clustered, but only here and there is the divergence sufficient distinctly to separate the clusters. More often the clusters are contiguous and can be only artificially separated where the density of the lines is least.

Thus it is clear that there are two steps in the study of classification. First the facts must be established as to the relative position of these lines of descent. In effect one must plot out in his imagination a cross-section of these genetic lines, the points representing the individuals examined, and the position of the points representing the variation of the individuals from the average of the group in the totality of their morphological characters. The second step is the interpretation of the results in terms of species. In the genus Aster, to which we are constantly returning for an illustrative example, there are certain pencils of lines that stand out distinctly in the plot. There is no difficulty in determining the definiteness of these

groups and there is no hesitation in pronouncing them distinct species. But there will be many cases where the groups are not distinct. There will be a segregation of dots at different points, a greater density of grouping, but the groups will not be definitely separated by blank areas. Lying between are scattered dots representing individuals which cannot be assigned definitely to any of the surrounding groups. The investigator must decide whether these indefinite but denser aggregations of dots represent species or whether the larger group which can be definitely separated from its surroundings shall be called a polymorphous species. Evidently we have to do here with species in the making and we may expect to find stages in the process. The decision as to the limitation of species must in some cases be arbitrary, no matter what standard for comparison be chosen, and may often be dictated by convenience or expediency. The sorely perplexed taxonomist can at least take comfort in the thought that he is not responsible for the vagaries of the plants and that it is not necessary for him to force the plants to conform to a concept. As some great philosopher has said, When in doubt tell the truth. We seek the truth, not the vindication of a theory. As stated above the taxonomic judgment is based chiefly upon experience. The worker determines the amount of variation in groups which the concensus of botanical opinion recognizes as species. One who is investigating asters should at the same time extend his observations to other groups of plants if he has not already accumulated a taxonomic experience. An inability to assign individuals to established species may not mean that the specimens are intermediates nor that the species are invalid. It may mean lack of knowledge on the part of the investigator.

After a worker has completed an investigation he should place the results on record for the benefit of science. The investigation has trained the worker and developed his judgment, but the results are lost to science unless they are published. Publication of results is a training in itself which adds greatly to a young man's efficiency. The points chiefly to be considered in preparing manuscript for publication are clearness, concise-

ness, and care in technique. The proper interpretation of results from observed data requires clear thinking. Clear thinking leads to clear writing. While it is occasionally true that a clear thinker may through carelessness write in an ambiguous or indefinite manner, he lays himself open to the suspicion that his thinking is no clearer than his writing. For the sake of himself and of his associates his results should be given with all the conciseness that is consistent with clearness. The literature upon all subjects is now so extended that no inconsiderable part of a scientist's time is devoted to reading the published results of others. Every man owes it to his associates to reduce to a minimum the time required to read the record of his results. Furthermore, a verbose report is often temporarily set aside with the intention of examining it when there is more time, an intention that is rarely fulfilled. If the report actually requires a wealth of detail there should at least be a succinct summary. We should learn early in our career that the really new and valuable points brought out in an investigation are usually few, and that these few points should be laid before our associates with clearness and precision, and not hidden in verbosity nor diluted by a mass of detail. To be able to compress statements of results into a small compass without loss in value to the scientific world is an evidence of distinction.

I cannot leave this subject without touching upon the question of technique, a question considered by some as trivial or inconsequential. I feel constrained the more to confide in you at this time because I have the misfortune to be a member of two editorial boards. The editors find that some writers will nearly choke to death over a comma, that others think punctuation marks are merely to be distributed over the page for ornamental purposes; that some use words to express their thoughts, that others use the same words but obscure their thoughts; that some are so burdened with technique that their thoughts seem imbedded in paraffin, that others look upon technique as an editor's instrument of torture. But seriously, technique is as important to the writer as to the painter, the sculptor, or

the engineer. And it should be as important to the writer of scientific articles as to the writer of novels, essays, or philosophical papers. A lack of attention to such details as punctuation, capitalization, and consistency in the abbreviation of bibliographic titles, and still more to careful diction, may with some justification be considered as indicating a similar lack of attention to details in carrying on the investigation which the paper records. The author should examine and correct his own paper with the same care and detached interest with which he, as an editor, would go over the manuscript of another. It is an evidence of scientific ability to be able to hold one's self firmly to every detail of his task, drudgery though it be, from the preliminary laying out of the plan of the work to the proper placing of the last comma in the finished manuscript.

At the beginning of his scientific career, every worker has before him an ideal which is a guide and an inspiration, a measure of accomplishment. This guide is usually the published paper of a prominent botanist, one in whom he has confidence and who has fired his zeal. As he advances along his chosen path he shifts his standard of accomplishment, but it should be always above or beyond. No man is perfect; no man's work is perfect. Only an ideal can be perfect. The axiom, the whole is twice the half, is an abstract truth, a perfect ideal. But we are never able to reach this ideal in practice. Our most careful measurements fall a little short of exact mechanical demonstration. The scientific worker progresses so long as his ideal is well in advance, be it the work of a teacher or leader, or be it abstract perfection toward which we all strive but which we never reach. But so soon as his ideal is his own best work, his progress ceases.

I have endeavored to outline to you the advantages to be gained in a study of some branch of taxonomic botany by those members of the society who are officially engaged in investigations along other lines. The local flora offers abundant opportunity for advancing scientific knowledge and for self-training in scientific methods. It cannot be claimed that taxonomic botany affords better opportunity for such training than does

any other branch of science. But we are already botanists; in the main our development will continue in this broad field. What I would point out is that now and again we can leave our desks and microscopes and laboratories for prairie and forest and stream, and that we have a field close at hand in which we can train our powers of observation and our taxonomic judgment, at the same time enhancing our enjoyment and extending the bounds of botanical knowledge.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHOTOMETRY.—*An "average eye" for heterochromatic photometry, and a comparison of a flicker and an equality-of-brightness photometer.* E. C. CRITTENDEN and F. K. RICHTMYER. Bureau of Standards Scientific Paper No. 299 (Bull. Bur. Stds., **14**: 87–113). 1917.

The comparison of lights of different colors is supposed to be based on an "average normal eye." This paper records an attempt to approximate the results of such an eye with typical color differences by using a large number of observers. In particular, results obtained by a flicker photometer and by an equality-of-brightness photometer, with different degress of color difference, are compared. In terms of the Ives-Kingsbury test solutions, for which the proposed normal ratio of transmissions (with a 4 wpc. carbon lamp) is 1.00, the average of 114 observers gives a ratio of 0.99. By using these test solutions results obtained on the flicker photometer by a small number of observers can be corrected so as to give normal values with a high degree of accuracy. On the average, equality-of-brightness measurements also vary in proportion to the test ratio, but erratic variations often overshadow these systematic differences. For sources having relatively high intensity in the blue, flicker values tend to fall below those obtained on the usual standard photometers, but the difference is comparable in magnitude with the uncertainty of the latter values.

E. C. C.

GEOLOGY.—*Anticlines in the Blackfeet Indian Reservation, Montana.* EUGENE STEBINGER. U. S. Geological Survey Bulletin 641–J. Pp. 281–305, with 2 plates and one figure. 1917.

This paper gives a brief account of the geologic formations in the Blackfeet Reservation and of their geologic structure, and a more de-

tailed description of the anticlines and of the formations that appear to contain oil or gas in southern Alberta and northern Montana. The general conditions in this region suggest that drilling in the Blackfeet Indian Reservation would have about the same chance of success as in the adjacent region in southern Alberta, extending from the international boundary northward to Calgary, a region in which drilling by over 40 companies during the last three years has been slightly successful. R. W. S.

GEOLOGY.—*Anticlines in central Wyoming.* C. J. Hares. U. S. Geological Survey Bulletin 641–I. Pp. 233–279, with map and 19 figures. 1916.

The area herein designated central Wyoming covers nearly 5000 square miles in Natrona and Fremont counties west of Casper and southeast of Lander, and includes no proved oil fields. This area was investigated primarily to ascertain the possibilities of oil, and as a result it was found that the Carboniferous and Cretaceous formations which produce oil in other Rocky Mountain fields are well developed in central Wyoming and in places the oil seeps from them, but in only a few places are these formations covered by impervious shale and within reach of the drill in folds favorable for the accumulation of oil and gas. The favorable folds are pointed out, but even these most favorable folds may be barren of oil. R. W. S.

GEOLOGY.—*Oil shale in northwestern Colorado and adjacent areas.* Dean E. Winchester. U. S. Geological Survey Bulletin 641–F. Pp. 139–198, with bibliography, 10 plates and 2 figures. 1916.

This report contains information showing the quantity and quality of oil that may be distilled from the richer beds of shale, the number of such beds at the different localities examined, and the general distribution of the shale throughout northwestern Colorado and adjacent parts of Utah and Wyoming. The results show that the shale of the Green River formation will yield a vast quantity of oil, gas sufficient to carry on the process of distillation, and fertilizer enough to enrich most of the farms of the Middle West, and that this reserve is ready whenever the demand is sufficient to warrant the establishment of a new industry to supplement the failing supply of petroleum from the oil fields. R. W. S.

GEOLOGY.—*Placer deposits of the Manhattan district, Nevada.* HENRY G. FERGUSON. U. S. Geological Survey Bulletin 640-J. Pp. 163–193. 1917.

The Manhattan district is in part a region of intensely contorted Paleozoic sediments and in part covered by Tertiary volcanics. The lodes from which the placer gold is derived occur principally in the Cambrian schist, but are of Tertiary age. Manhattan Gulch, draining the central part of the district, has yielded a large amount of placer gold. The bed-rock gravels from which the bulk of the placer gold has been obtained were laid down in Pleistocene time, and the accumulation of gold is the result of successive concentrations. Of particular interest is the regular increase in purity of the placer gold with the distance from its source. In a distance of two miles down the gulch the fineness of the gold changes from 700 to 740 parts per 1000.

H. G. F.

GEOLOGY.—*Economic geology of Gilpin County and adjacent parts of Clear Creek and Boulder Counties, Colorado.* EDSON S. BASTIN and JAMES M. HILL. U. S. Geological Survey Professional Paper 94. Pp. 379, with 23 plates and 79 figures. 1917.

Gilpin County and the adjacent portions of Boulder and Clear Creek Counties, Colorado, lie nearly west of Denver in the heart of the Front Range of the Rockies. Central City, the seat of Gilpin County, is the oldest lode-mining camp in Colorado and in total production one of the most important.

Most of the rocks of the region are pre-Cambrian in age. Some of them have undergone severe dynamic metamorphism; others are practically unmetamorphosed. The pre-Cambrian rocks are intruded by a great variety of much younger igneous rocks, most of them porphyritic in texture. Though they show some diversity in age, all are believed to have been intruded in Tertiary time. They occur as stocks and dikes, and are abundant in all parts of the region.

The region forms part of a broad mineralized belt which embraces most of the economically important mining camps of Colorado. The ores of the region may be classed, according to the metals which give them their predominant value, as (1) gold-silver ores, which constitute the main economic resource of the region; (2) uranium ores, which occur in a few places only but are of much interest as a source of radium; (3) tungsten ores, which form the basis of the tungsten industry of Boulder County, the most productive center for this metal in the

United States; (4) ores worked primarily for copper; (5) titaniferous iron ores. Most of the ores occur as veins, as a rule steeply dipping, which are in part fissure fillings and in part replacements of various rocks along zones of fracturing. All the ores of the region are believed to be genetically connected with the Tertiary (?) intrusive rocks.

Enrichment in the Central City region has been confined mainly to the class of gold-silver ores. Enrichment in gold appears to be confined almost exclusively to portions of the ore deposits above or immediately below the ground-water level. Silver enrichment is confined to the ground-water zone. Enrichment in copper is nowhere conspicuous. R. W. S.

GEOLOGY.—*Brachyceratops, a ceratopsian dinosaur from the Two Medicine formation of Montana, with notes on associated fossil reptiles.* CHARLES W. GILMORE. U. S. Geological Survey Professional Paper 103. Pp. 44, with 4 plates and 57 figures. 1917.

This paper gives as complete and detailed a description of the skeletal anatomy of *Brachyceratops montanensis* as the material at hand will permit, and discusses briefly in systematic order other forms represented by specimens in the collection made in 1913 on the Blackfeet Indian Reservation.

The stratigraphy of the Two Medicine formation is discussed by Eugene Stebinger. Vertebrate fossils are found throughout the upper part of the Two Medicine formation and nearly all of them belong to the class Reptilia. The great number of trachodonts found appears to indicate that these were the most abundant dinosaurs of the epoch. Next to the Trachodontidae, the Ceratopsidae were most abundant. Fragments of turtles are plentiful; a few teeth and single bones of extinct crocodiles, and isolated scales and plates of ganoid fishes were found. The vertebrate fauna of the Two Medicine formation, as represented by this small collection, although too meager to serve as a basis for close comparisons with related faunas, accords with the stratigraphic evidence for the correlation of the upper part of the Two Medicine formation with the dinosaur-bearing beds of the Judith River and Belly River formations. R. W. S.

MINERALOGY.—*Notes on alunite, psilomelanite, and titanite.* EDGAR T. WHERRY. Proc. U. S. Nat. Mus., **51:** 81–88. 1916.

Includes descriptions with analyses and discussions of the composition of two specimens of alunite, one of psilomelanite, and one of titanite. E. T. W.

MINERALOGY.—*Glauberite crystal cavities in the Triassic rocks of eastern Pennsylvania.* EDGAR T. WHERRY. American Mineralogist, **1**: 37–43. 1916.

The crystal cavities in the sedimentary rocks, previously mentioned in connection with announcement of the character of lozenge-shaped cavities in zeolite deposits (Journ. Wash. Acad. Sci., **6**: 181–4. 1916) are described in detail. They are shown to agree crystallographically with the mineral glauberite. Pseudomorphs of calcite after glauberite are also described. It is believed that the glauberite formed as the result of evaporation of lake waters of Triassic times. E. T. W.

TECHNOLOGY.—*Glasses for protecting the eyes from injurious radiations.* W. W. COBLENTZ and W. B. EMERSON. Bureau of Standards Technologic Paper No. 93. Pp. 14. 1917.

The object of the present paper is to give the general characteristics of certain newly developed glasses sometimes used for protecting the eye from radiant energy, especially from the infra-red or so called heat rays. Because of the difficulty in reproducing the same color in different melts, no attempt is made to give specific data on the transmission for a given thickness of glass. The data given are representative of an extensive group of glasses available for protecting the eye from (1) the ultra-violet, (2) the visible, and (3) the infra-red rays.

For protecting the eye from ultra-violet light, black, amber, green, greenish-yellow, and red glasses are efficient. Spectacles made of white glass afford some protection from the extreme ultra-violet rays. For shielding the eye from infra-red rays deep black, yellowish-green, sage green, gold plated, and bluish-green glasses are efficient. For working near furnaces of molten iron or glass if considerable light is needed, a light bluish green or sage green glass is efficient in obstructing the infra-red rays. For working molten quartz, operating oxy-acetylene or electric welding apparatus, or other intense sources of light, it is important to wear the darkest glasses one can use whether black, green (including gold plated glasses), or yellowish-green, in order to obstruct not only the infra-red but also the visible and the ultra-violet rays. Of the infra-red rays emitted by a furnace heated to 1000 to 1100°C about 99 per cent are obstructed by gold plated glasses, about 95 per cent by sage green or bluish green glasses, about 80 per cent by very deep black glasses, and about 60 per cent by greenish yellow glasses. W. W. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 786th meeting was held March 17, 1917, at the Cosmos Club, President BUCKINGHAM in the chair; 51 persons present. The minutes of the 785th meeting were read in abstract and approved.

Mr. WILLIAM BOWIE read a paper on *Our present knowledge of isostasy,* which was illustrated by a number of slides. After reviewing briefly the conclusions reached by Prof. Hayford, Mr. Bowie discussed the recent researches in gravity and isostasy.

In these investigations the results obtained at 219 stations in the United States, 42 stations in Canada, 73 stations in India, and 40 stations in other countries, were used. Isostasy seems to be about as complete in each of the countries where extensive data were available as in the United States, although it was not possible to make certain tests for the other countries, owing to lack of certain detailed data.

Isostasy in the United States, for the whole area, is practically perfect. For local areas gravity is, on an average, 0.020 dyne from normal. This anomaly corresponds to a mass of material of indefinite horizontal extent and thickness of about 600 feet. Whether this average deviation from normal in gravity is caused by a lack of isostatic compensation or whether it is caused by the presence of extra light or extra heavy material in the outer portion of the earth's crust close to the station is a problem that cannot be entirely solved by the use of present data.

It was found, during the investigations of the Coast and Geodetic Survey, that the gravity anomaly showed some relation to the geological formation on which a station is located. For instance, on the pre-Cambrian formation, where the rocks are denser than normal, gravity is in excess at nearly all stations. For the stations on the Cenozoic formation, the density of the material of which is somewhat less than normal the anomaly tends to be negative and all of the larger anomalies of those stations are negative. There was not found any relation between the gravity anomaly and the densities of the materials of the Mesozoic and Paleozoic formations.

Various tests were made for determining the most probable depth of compensation. The result was a depth of 95 kilometers, but the speaker emphasized the fact that this depth may be very indefinite

and may not exist as a definite surface. It is only in case of a uniform distribution of the compensation that there could be a definite surface limiting the distribution of compensation. It was stated that the uniform distribution was adopted in the computations to facilitate the progress of the work. Any one of several distributions, other than that of uniform distribution, would give practically the same results. This is somewhat of a surmise, as no elaborate tests were made.

The application of the theory of isostasy to the gravity data made it possible to derive a formula for giving gravity at sea level at any latitude. 348 stations in the United States and other countries were used in the derivation of a number of formulas on various assumptions. One of them, the best formula probably in the world, is $\gamma = 978.039$ $(1 + 0.005294 \sin^2 \phi - 0.000007 \sin^2 2\phi)$ in which γ is the value of gravity sought and ϕ is the latitude of the station.

Discussion. Mr. G. K. Burgess asked about the possibility of using the Eötvös torsion balance for determining variations in the intensity of gravity, and about the complete absence of magnetic materials in the pendulum used.

Mr. Bauer questioned whether the depth of compensation did not vary with the topography, and Mr. Bowie called attention to the fact that the data from stations located on plains did not permit of a solution for the depth.

Mr. W. F. G. Swann then gave a paper on *The origin of the earth's electric charge.* Measurements of the variation of the penetrating radiation with altitude point to the upper atmosphere as the origin of a part of this radiation. The whole of the penetrating radiation is probably of the γ ray type, but the part which reaches the Earth's surface from the outer atmosphere is naturally the most penetrating part. Indeed, it is so penetrating that it passes through a thickness of air which would be equivalent, in absorptive action, to a column of mercury 76 cm. high, if absorption coefficients were simply proportonal to density and were independent of material. The γ ray radiation from the outer layers of the atmosphere will consequently be very "hard," and, in accordance with the known results of laboratory experiments, we must conclude that the negative corpuscles which it emits from the air molecules are emitted almost entirely in the direction of the radiation, and further, that they can have a range in air at least equal to that of the swiftest β rays from radium products. The emission of corpuscles by these γ rays will consequently result, at each point of the atmosphere, in a downward current of negative electricity, which we shall call the corpuscular current. This corpuscular current will charge the Earth until the return conduction current balances the corpuscular current at each point of the atmosphere.

Taking, for the purpose of this abstract, a simplified case where the penetrating radiation considered is all directed vertically downwards, if q is the number of corpuscles liberated per cubic centimeter per second by the penetrating radiation, and h is the average distance

which a corpuscle travels from its point of origin, the corpuscular current density will be

$$i = qeh$$

where e is the electric charge.

If account be taken of the fact that the radiation passing through 1 sq. cm. comes from all directions lying within a hemisphere, the result is to introduce a factor of $\frac{1}{2}$, so that

$$i = \frac{1}{2}\, qeh$$

The average value of the air-earth current density as obtained from several stations is 6.7×10^{-7} E.S.U., so that if q be taken as 3, which is about equal to the number of pairs of ions produced per cubic centimeter per second in a closed vessel, as a result of the part of the penetrating radiation in question, the value of h necessary to account for the measured current-density is 9 meters. This value is quite within the range of posibility, since Eve has observed β rays at a distance of 7 meters from the source.

A few minor difficulties present themselves. Thus, for example, near the surface of the Earth a considerable portion of the whole penetrating radiation comes from the soil, and is directed upwards, but this difficulty disappears when it is remembered that the average "hardness" of this radiation is very much less than that of the radiation which reaches the Earth from the outer layers of the atmosphere. Again, it might appear that the corpuscles set free by the penetrating radiation should, on account of their great energy, produce in the atmosphere many more ions per second than are actually found to be produced. This difficulty and others of allied nature become greatly reduced in magnitude, however, when considered in the light of our present knowledge of the action of very swift β rays when passing through a gas.

Discussion. Mr. BAUER spoke of the possibility of some of the penetrating radiation being of solar origin.

DONALD H. SWEET, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 568th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, March 24, 1917; called to order at 8 p.m. by President HAY; 31 persons in attendance.

Under the heading of book notices Dr. L. O. HOWARD said he had carefully examined the work on beetles presented to him at the 567th meeting of the society by Dr. H. M. Smith, and found that it was a hand made copy of all the descriptions of the North American beetles contained in a large French monograph dealing with that group of insects.

The regular program consisted of three communications:

W. P. Taylor: *Notes on Aplodontia.* Dr. Taylor said the peculiar west American rodent *Aplodontia*, discovered by Lewis and Clark, is the sole living representative of the family Aplodontiidae. It is exclusively North American in origin, development, and distribution. Found in Tertiary times in the Great Basin region and even as far east as South Dakota, the family is now limited to the Pacific Slope of North America. *Aplodontia* is colonial and fossorial, feeding exclusively on the vegetation in the vicinity of its burrows. The aplodontid phylum is noteworthy for its extreme conservation. During a lapse of time which sufficed to transform the horse from the Miocene *Merychippus* type to the larger Pliocene *Pliohippus*, there appears to have been no appreciable change in the tertiary species *Aplodontia alexandrae*; and during the time when the *Merychippus* type of horse became transformed into the modern *Equus* with modifications in every bone in the body and characters generically probably twice removed, the aplodontid stock has undergone comparatively little change, all observed variations, as at present recognized, falling within the limits of a single genus.

Dr. Taylor's communication was discussed by Messrs. T. E. Wilcox, N. Dearborn, A. Wetmore, L. O. Howard, N. Hollister, and R. W. Shufeldt.

W. Dwight Pierce: *The extaordinary strepsipterous type of parasitism.* Mr. Pierce spoke of the extraordinary type of parasitism displayed by the insect order Strepsiptera. He called attention to the great diversity in form between the male and female *Strepsiptera*. All species of this order are parasites in the bodies of bees, ants, wasps, leafhoppers, and grasshoppers. The only part of the body which can be seen when in the host is the cephalothorax which protrudes between the segments of the host abdomen. The females are legless and blind, and have no appendages except mandibles, which are of no value after the cephalothorax has been protruded from the body. They give birth to living young which emerge from the body of the parent through a canal between her unshed larval skin, and the true adult, reaching the body of the host through an opening between the head and thorax of the parent. These young, in order to find their next host, must be deposited on some flower visited by the species which they parasitize. They are then carried by the nest-building hosts to their nests and there find larvae to attack. Shortly after entering the new hosts they lose their legs and become very degenerate in appearance. The males have one pair of wings, the front pair being reduced to tiny balancers. They are very active creatures with slender legs, immense stalked eyes which look like raspberries, and degenerate mouth parts. These insects are world wide in their distribution, but very rare. Mr. Pierce's communication was discussed by Messrs. L. O. Howard, E. A. Goldman, and W. P. Hay.

R. W. Shufeldt: *Zoological statuary at the National Capital.* Dr. Shufeldt, after relating his experiences with the sculptor, John Rogers, in 1872, and with others in the studios of New York City forty years

R. W. Shufeldt: *Zoological statuary at the National Capital.* Dr, Shufeldt, after relating his experiences with the sculptor, John Rodgers. in 1872, and with others in the studios of New York City forty years thereafter, pointed out how generally it was the case everywhere that sculptors ignored the teachings of biologists, carrying their idealism to such an extreme that many of the elaborate pieces, intended as ornaments in places of prominence in cities, were untrue to nature, highly rediculous in conception, as well as in execution. This rule applied to a large part of the sculptural pieces in the City of Washington, and to this there were but too few exceptions. Among these latter were the tigers and buffaloes of Mr. Proctor. Through the use of his lantern slides Dr. Shufeldt illustrated his remarks and criticisms of a considerables number of the pieces of animal sculpture about the city. Exception was taken to the employment of nonindigenous animals as American models for such purposes, and especial objection was made.to the lion, which, the speaker said, should be supplanted bp our own native forms, as the elk, moose, cougar, and other types.

Dr. Shufeldt's communication was discussed by Messrs. L. O. Howard, H. E. Ames, W. P. Hay, J. W. Gidley, G. W. Baird, and others.

M. W. Lyon, Jr., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 509th meeting of the Society was held in the Lecture Hall of the Public Library on March 19, 1917. On this occasion Dr. Fay-Cooper Cole, of the Field Museum of Natural History, Chicago, delivered a lecture before the society on *The pagan tribes of the Philippines.*

He first took up the peopling of the Islands and the intermingling of peoples which has resulted in the present population. The pigmy blacks or Negritos were held to be the aboriginal inhabitants of the islands. They were driven back from the coasts, and finally to a few isolated regions by the pressure of invaders, most of whom came in from the south. Many of the pigmies were enslaved or otherwise merged with newcomers and, as a result, traces of this intermixture are now to be seen in every tribe of the Philippines.

The invading peoples are believed to have come in several waves, not as a part of a great single movement. The earliest of these waves appears to have been made up of a people who were physically closely lalied to the Polynesians. They were followed by successive invasions of primitive Malays—a people with closer affinities to the Mongoloid people of Southern Indo-China and the earlier inhabitants of Burma. These early inhabitants appear to have intermarried to a great extent, and later to have mixed with newcomers so that today the population is of a very complex nature. Dr. Cole showed a number of slides of members of the Bukidnon tribe of Central Mindanao. In this group three types continually appear—oftentimes in the same family. The first type has distinct negroid features showing the admixture of Negrito blood; the second closely approximates the Christianized Visayan of the Coast; while the third element is made up of people who in all but color closely resemble Caucasians.

The effect of movements of alien peoples and beliefs into Malaysia, in historic times, was also sketched. Traces of the Hindu-Buddist movement are evident especially in the folk-lore; while the great effects of the introduction of Mohammedism and Christianty on the bulk of the population are a part of historic record.

The greater part of the evening was devoted to a description of the most fundamental facts of the religious, social, and economic life of three pagan tribes—the Bagobo of Southern Mindanao, the Bontoc Igorot, and the Tinguian of Northern Luzon.

The Bagobo live on the lower slopes of Mt. Apo, the highest mountain of the Philippines. Near the summit of this mountain is a deep fissure from which clouds of sulphur fumes and steam are continually rising, while frequent earthquakes give evidence of latent energy. In this peak a great host of spirits are supposed to dwell, but the most powerful are Mandarangan and Darago, a male and a female, who are the patrons of the warriors and in whose honor human sacrifices are held each year. Other spirits look after the workers in brass and in iron, and the weavers, and some dwell in the fields and protect the crops; while each family has its special protecting spirit. Offerings of food both cereal and of flesh and blood are made to all of these, as well as to the low mean spirits which seek to injure mortals; but to the greatest and most powerful of all the spirits only white offerings of rice and the like are presented. There is also a belief in a class of powerful spirits who inhabit the realms above the earth. These beings take no interest in the affairs of men, and no offerings or supplications are made to them. Each person is thought to have two spirits or souls—one on the right side and one on the left. The first of these finally goes to the land of the dead, while the second continues to roam the earth as a flesh devouring *buso*, or evil spirit.

The Bagobo are ruled over by *dato* or petty rulers, who in turn are subservient to the chief *dato*. Slavery and polygamy are both found in the tribe, but the slavery is of a mild type, and it is possible for the members of this class to become merged into the general population. Agriculture is of great importance, though conducted in a very primitive fashion, but rice terraces are quite unknown.

Going to Northern Luzon Dr. Cole showed the Igorot and Tinguian living under similar geographic conditions, their territories joining along the northwestern, border of Bontoc. The whole belt is exceedingly mountainous, the jungle being absent except in the deep valleys, and the rivers are small except during the rainy season when they become rushing torrents. Under these conditions it would be impossible to support a large population either by hunting or fishing, and the people have taken seriously to agriculture. The rugged nature of the land has caused them to terrace the mountain sides and in connection with these elevated fields, an elaborate system of irrigation has been worked out. Both tribes have, until recent years, been ardent head hunters, but the motives for taking the skull as well as the final disposition of the trophy varies in the two districts. In language

and physical type the people are much alike, but there most of the similarity ends.

A Bontoc village is divided into *ato* or political divisions each one of which is governed by an oligarchy of old men. The leaders of the various *ato* meet from time to time to decide matters of importance to the village. These *ato* are also exogamic divisions of the settlement and each has its man's house in which all unmarried men and boys must sleep. It also serves as a council house and as the storage place for drums and other ceremonial paraphernalia. Here also are kept the skulls of enemies. Unmarried girls sleep in the *olag* or girls' house from the age of about four years until their marriage. Trial marriage is common, a final union seldom taking place until the birth of a child is assured.

Going to the Tinguian a radically different type of house construction is encountered. The villages are not divided into political or exogamic groups; the man's house and the girls' dormitory are not found, nor is trial marriage practiced. The government of the village is in the hands of a head man known as *lakay*, who may if he desires call in other old men to aid him in the decision of important matters.

Dr. Cole ended his talk with a somewhat detailed description of the religious beliefs of the Tinguian; the possession of their mediums by the spirits; and the ceremonies conducted to bring health and prosperity to the group.

About one hundred colored lantern slides were used in illustration.

The 510th meeting of the Society was held at the Natural History Building of the National Museum, April 3, 1917. At this meeting Leo J. Frachtenberg, of the Bureau of American Ethnology, presented a paper on *The religious ideas of the Northwest Coast Indians.*

Dr. Frachtenberg stated that four important features of the religious ideas noted among the Indians of this region are: (1) An intensive animism; (2) a belief in the powers of supernatural beings as dwarfs and giants; (3) a belief in the existence of guardian spirits; (4) a complete absence of the social phase of religion.

According to Dr. Frachtenberg many religious ideas are common to all the tribes of the Northwest Coast, yet the northern and southern portions of this area are found to differ in cosmogony. The tribes in the extreme southern portion believe that the world was created out of a watery mist, the Transformer enlarging a small piece of land until it became large enough for habitation. The tribes of the northern portion are satisfied with a world whose origin is not explained. They hold, however, that the Transformer (Creator) first made man and the members of faunal and floral kingdoms, and at a later time returned and improved this creation. Two visits of the Transformer are typical of this region. In the south the Transformer (Creator) and the Trickster are separate individuals, while in the north they are unified. In the south the Transformer makes all that is good, and the Trickster is held responsible for all the bad elements; while in the

north there is no such dissociation. Good and evil things were alike created by the Transformer.

The Northwest Coast Indians believe that an individual comprises a body inhabited by two "souls" and a "ghost." In a slight illness the "outer soul" becomes separated from the body, in a serious illness the "inner soul" wanders to the "country of souls" but may be recalled by the shaman. When death occurs the "ghost" also departs and the shaman has no further power. The "country of souls" contains two division, one inhabited by recently arrived souls, the other by souls which have been there for a longer time. On their journey to this land the souls pass a "rest-house," then a "lake" and a "berry-ground." Their way is barred by a "spring-pole," and they must cross a "rotten log," the final barrier being a wide river.

No ritual or systematic form of supplication is found among these Indians, indeed it may be said that guardian spirits take the place of deities. Every man and woman possesses one or more guardian spirits each of which has its special sphere of influence. Thus there are guardian spirits for securing good weather and plenty of seal or whale, guardian spirits for success in hunting, and for help in making baskets and canoes. No offerings accompany a request to a guardian spirit. Crude representations of these spirits are seen on the implements and on the house-posts of their owners.

The shamans receive their power from a multitude of spirits. Certain shamans are considered to have power to cure sickness, while it is believed that others can "steal a man's soul," causing either serious illness or death. Large gifts are exacted by the shamans, who are both respected and feared.

In the discussion which followed the reading of the paper Dr. J. R. Swanton called attention to the nascent dualism and monism in the religious beliefs of the Indians of the southern and northern areas considered by the speaker. Dr. I. M. Casanowicz noted the strange fact that many primitive religious ideas bear a resemblance to the most advanced religious ideas of the present time. Dr. J. W. Fewkes said that primitive Indians are so low in the cultural scale that they develop only the most general religious principles, these being modified by the several geographic areas inhabited by them. He stated further that there is no unity in the primitive religions of the American Indians, though some parallelisms are found between the beliefs held in different areas. Dr. Truman Michelson mentioned some differences between the religious ideas of the Northwest Coast Indians and those of the Algonquian tribes, one of the chief differences being that the latter do not believe in a plurality of souls.

Frances Densmore, *Secretary*.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, May 5: The Biological Society, at the Cosmos Club, at 8 p.m.

Thursday, May 10: The Chemical Society, at the Cosmos Club, at 8 p.m.

Saturday, May 12: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

I. G. PRIEST and C. G. PETERS: *An interferential method for measuring the expansion of very small samples* (Illustrated.) 30 minutes.

J. D. EDWARDS (by invitation): *Rapid determination of gas density.* (Illustrated.) 30 minutes.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh day of each month.

CONTENTS

Original Papers

Page

Geophysics.—Live sea lava at Kilauea. T. A. Jaggar .... [illegible]

Stratigraphy.—Tongue, a new stratigraphic term, with illustrations from the Mississippi Cretaceous. Lloyd William Stephenson .... [illegible]

Botany.—Taxonomic botany and the Washington botanist. A. S. Hitchcock .... [illegible]

Abstracts

Photometry .... [illegible]
Geology .... [illegible]
Mineralogy .... [illegible]
Technology .... [illegible]

Proceedings

The Philosophical Society of Washington .... [illegible]
The Biological Society of Washington 371
The Anthropological Society of Washington 373

Vol. VII

No. 10

May 19, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. VII MAY 19, 1917 No. 10

GEOLOGY.—*On the terms aphrolith and dermolith.* T. A. JAGGAR, JR., Hawaiian Volcano Observatory. (Communicated by Arthur L. Day.)

Dutton[1] in describing Hawaiian volcanoes made use of the terms aa and pahoehoe, and these words of Hawaiian origin have been somewhat adopted by American geologists. Some English geologists object to them strongly and continental usage is various in the matter. Aa lava of the Hawaiians is characterized by a peculiar mechanism of solidification of olivine basalt, whereby a magma surcharged with gas so froths or foams in its surface layer that on solidification this layer shrivels and separates into discrete scoriaceous units, in some places light and pumiceous, but elsewhere heavy and slaggy. The extreme pumiceous type is the limu, or "thread-lace scoria" of Dana. The lava flow beneath solidifies as a coarsely vesicular body grading downward into crystalline rock which has no known petrographical peculiarity different from any other type of flow. The boundary surface at the top of the continuous sheet and below the discontinuous layer of scoriae is revealed at many places on the shoreline of Hawaii, where the ocean has swept the loose material away. In these places the surface revealed is rugose and in detail much like the scoriaceous fragments, but it sometimes exhibits coarse ropy forms and rough festoons

[1] DUTTON, C. E. *Hawaiian Volcanoes.* 4th Ann. Rep. U. S. Geol. Surv., 1882-83.

in plan. The distinctive feature of typical aa, however, is the shrinkage of the surface into units from a few centimetres to several metres in diameter, each unit being complete in itself and commonly free from broken surfaces. Such lava is spoken of in text books which have not adopted the Hawaiian word, as fragmentary lava, block lava, or scoriaceous lava, and in the southwestern states the Mexican word "malapai" or "malapis" is used for the vast fields of aa which there occur. In the Cordilleran belt and elsewhere great bodies of ancient aa are called pyroclastics, breccias, and agglomerates indiscriminately, along with explosion products that are of totally different origin. Aa makes a pyroclastic where igneous matrix is apt to be identical with the contained fragnents, and the fragments are of irregular lumpy outline.

The pahoehoe lava of the Hawaiians, on the other hand, is distinguished by smooth surfaces which result from the formation of a glassy membrane or skin. The mode of congelation of olivine basalt magma advancing as a pahoehoe flow is very strikingly different from that of an aa flow. The surface of the lava lake of Kilauea in all stages of its crusting is typically pahoehoe. As the heat is radiated from the surface, solidification forms a dermal layer made of filaments of glass remnant from expanding bubbles filled with gas, and these show no tendency to burst explosively, but incessantly crowd into the interstices of the stretching and rending layer of filaments of previous formation. The result is a skin not usually gas tight and exhibiting extraordinary diversity of texture. Solidification proceeds from without inwards, the skin reaches various thicknesses and then folds, and the folding distributes itself somewhat like the moraines of a glacier with festoons drawn downstream farthest along the middle line and retarded at the two sides. At the sides there are lengthwise curtains produced by the longitudinal drag between resistant cooling margins and the festooned stream in the middle. At the front, toes of the molten fluid push out from under the skirts of the flow in peculiar tuberous bodies, which tend to congeal on all sides and may even lift their tips vertically and solidify. They ap-

pear to be blown by expanding gas, for the axis is almost tubular in its coarser vesicularity. The spasmodic renewed advance of a pahoehoe flow is frequently characterized by pushing out from under a skirt of crust, in contrast to the aa flow which appears to solidify from below upward and to advance by overriding its already solidified lobes. Pahoehoe lava is variously mentioned in the text books as fluent, smooth, ropy, or corded lava.

Visually the two types of lava, in mobility and temperature, appear much alike while incandescent and flowing rapidly as golden streams. With the beginnings of solidification, however, the difference is pronounced, pahoehoe forming skins and aa forming knobs and cinders like a bed of hot coals. The cooling front of an aa flow is full of flames through the apertures of the blocks. The front of a pahoehoe flow shows no flames detectable by eye. The aa flow at its front is in a brittle semi-solid condition, slabs rifting away and falling forward from a mass beneath that resembles hot iron. Pahoehoe, on the other hand, bellies its crust forward, escapes as a viscous pudding and this in turn skins over, the whole movement resembling the advance of candy or tar.

The explanation of the physico-chemical difference between the two types remains to be discovered, as chemical analysis in the same region has as yet revealed no distinction. It seems probable that the quantity of confined gas, in solution or in bubble form, for each unit of volume of melt, controls the mode of freezing. Possibly the gases are nearer equilibrium in pahoehoe than in aa. The heat equation plays an important role, and this involves reaction between the gases as well as their oxidation in air. Gas expansion may be more rapid in aa and so induce internal solidification. Furthermore, there are enormous differences in the state of oxidation of the iron at the moment of cooling, and as yet we know nothing of the progress of crystallization in the field. With so many variables there is no cause for wonder that the distinction is as yet unexplained.

Between pahoehoe and aa flows in Hawaii there are unquestionably gradations of many appearances and perhaps of many

kinds, but this the writer doubts. By this is meant that the gradations may be mixtures of two substances rather than stages of one substance. This is only a suggestion in the present condition of our knowledge, based on the discovery, reported in a previous note, that the lake bottom or bench magma of Kilauea was found solidified as aa, whereas the lake magma solidifies as pahoehoe.

In view of the diversity of usage cited above, and of the confusion which results when pahoehoe crusts break up and make a "fragmentary" or "block" lava not at all of aa character, or when aa flows are revealed scoured bare and show "ropy" or "corded" aspect without being in the least of pahoehoe origin, I believe that volcanology needs a terminology scientifically descriptive of the two groups of effusive magmatic bodies, and capable of adaptation as adjectives, adverbs, or nouns in any modern language.

Accordingly I propose for pahoehoe the term DERMOLITH (Greek, skin + stone), to cover all those forms of effusive lava which manifest subaerially a surface skin or crust, capable of wrinkling or folding, as the chief distinguishing character.

For example, dermolithic basalts are common in Hawaii, Samoa, Iceland, Reunion, and on the Snake River plains, but dermolithic flow has not been identified at Lassen's Peak. At Mauna Loa near the vents of 1916, the lava flowed dermolithically in a coarse way, but exhibited a much rougher texture than the characteristic dermolith of Halemaumau. On the floor of Kilauea crater great fields of dermolith extend far and wide.

I propose for aa the term APHROLITH (Greek, foam + stone), to distinguish those effusive lavas or crater bodies which tend on solidification to subdivide surficially into complete irregular lumpy vesicular units, the crust surfaces of the continuous mass having protuberances of similar rugged character.

For example, aphrolithic lava flow has been dominant on the southern flank of Mauna Loa since 1868, the flow of that year being partly dermolithic. It would appear also, from the observations of 1917, that aphrolith occupies the bottom of the Kilauea lava lake and that hence the solidification of the interior

of the bench magma must proceed aphrolithically. Supposing the cumulo-domes of Bogoslof and Pelée to be essentially aphrolith, it is a matter of great interest to determine whether any dermolithic flow, however small, took place in those magmas. At Soufriere in St. Vincent, and also on Bandaisan, there are aphrolithic blocks of fresh rock quite distinct from the angular fragments, and apparently representative of the subterranean magmas which produced the explosions.

If these terms are adopted, it is hoped that they will not be changed in English to the *-lite* termination, as Harker[2] insisted on doing for "batholite," etc. The *-lite* syllable is needlessly confusing, on account of the innumerable rock and mineral names so ending. Harker's contention is that "-lith" is continental and not English, but this is disproved by such a word as *monolith*, which is accepted English of Greek derivation.

GENETICS.—*Observed changes in hereditary characters in relation to evolution.*[1] H. S. JENNINGS, Johns Hopkins University.

The problem of the method of evolution is one which the biologist finds it impossible to leave alone, although the longer he works at it, the farther its solution fades into the distance. The central point in the problem is the appearance, nature, and origin of the heritable variations that arise in organisms; the changes that occur in the hereditary constitution. I have for a long time been studying the appearance of heritable variations in certain lower organisms. Having satisfied myself as to the nature of the variations that arise in the creatures that I have studied, I have looked about to see what other workers have found; and to determine whether any unified picture of the matter can be made. Can we bring these facts which experimental work has brought out into relation with the method of evolution? Can we say that they exclude any particular theory?

[2] HARKER, A. Natural History of the Igneous Rocks.

[1] A lecture delivered before the Washington Academy of Sciences, March 15, 1917.

Can we say that they leave certain views admissible? Can we go farther and say that they make certain views probable? I shall hardly be so bold as even to ask whether they establish any particular views, though even that has been at times affirmed.

These questions have, of course, been raised thousands of times; it is only because knowledge does advance, because experimental work has been enormously multiplied of late, that there is reason to bring them up anew. I am going to try to put before you the present situation as it appears to me.

What we may call the first phase of the modern experimental study of variation is that which culminated in the establishment of the fact that most of the heritable differences observed between closely related organisms—between the members of a given species, for example—are not *variations* in the sense of alterations; are not active *changes* in constitution, but are permanent diversities; they are static, not dynamic. This discovery, like that of Mendelian heredity, was, as you know, made long ago by the Frenchman Jordan; but, as in the case of Mendelism, science ignored it and pursued cheerfully its false path till the facts were rediscovered in recent years. All thorough work has led directly to this result: that any species or kind of organism is made up of a very great number of diverse stocks, differing from each other in minute particulars, but the diversities inherited from generation to generation. This result has in recent years dominated all work on the occurrence of variations; on the effects of selection; on the method of evolution. The condition is particularly striking in organisms reproducing from a single parent, so that there is no mixing of stocks; I found it in a high degree in organisms of this sort which I studied. Thus the in usorian Paramecium I found to consist of a large number of such heritably diverse stocks, each stock showing within itself many variations that are not heritable.[2] *Difflugia corona*, which I have recently been studying, shows the same condition in a marked degree.[3] As you know, a host of workers have found similar conditions in all sorts of organisms. It led to the

[2] See JENNINGS, 1908, 1909, 1910, 1911. (See Bibliography.)

[3] JENNINGS, 1916. (See Bibliography.)

idea of the genotype (Johannsen), as the permanent germinal constitution of any given individual; it supported powerfully the conception of Mendelism as merely the working out of recombinations of mosaic-like parts of these permanent genotypes. The whole conception is in its essential nature static; alteration does not fit into the scheme.

This discovery seemed to explain fully all the observed effects of selection within a species; but gave them a significance quite the reverse of what they had been supposed to have. It seemed to account for practically all the supposed variations that had been observed; they were not variations at all, in the sense of steps in evolution; they were mere instances of the static condition of diversity that everywhere prevails. Jordan, the devout original discoverer of this condition of affairs, maintained that it showed that organisms do not really vary; that there is no such process as evolution; and indeed this seems to be the direct logical conclusion to be drawn. In these days of plots and spies, the evolutionists might almost feel that the enemy had crept into their citadel and was blowing it up from within.

Now, this multiplicity of diverse stocks really represents the actual condition of affairs, *so far as it goes.* Persons who are interested in maintaining that evolution *is* occurring, that selection *is* effective, and the like, make a very great mistake in denying the existence of the condition of diversity portrayed by the genotypists. What they must do is to accept that condition as a foundation, then show that it is not final; that it does not proceed to the end; that the diverse existing stocks, while heritably different as the genotypists maintain, may also change and differentiate, in ways not yet detected by their discoverers.

But of course most of the adherents of the "orthodox genotype theory" do not maintain, with their first representative Jordan, that no changes occur; that all is genetically static in organisms. Typically, they admit that *mutations* occur; that the genotype may at rare intervals transform, as a given chemical compound may transform into another and diverse compound. We all know the typical instances: the transforming mutations of Oenothera; the bud variations that show in a sudden change of

color or form in plants; the dropping out of definite Mendelian units in Drosophila and elsewhere; the transformation of particular Mendelian units into some other condition.

So much then may serve as an outline of a prevailing theory; organisms forming a multitude of diverse strains with diverse genotypes; the genotype a mosaic of parts that are recombined in Mendelian inheritance; selection a mere process of isolating and recombining what already exists; large changes occurring at rare intervals, through the dropping out of bits of the mosaic, or through their complete chemical transformation; evolution by saltations.

Certain serious difficulties appear in this view of the matter; I shall mention merely two of them, for their practical results. One is the very existence of the minutely differing strains, which forms one of the main foundations for the genotype theory. How have these arisen? Not by large steps, not by saltations, for the differences between the strains go down to the very limits of detectibility. On the saltation theory, Jordan's view that these things were created separate at the beginning seems the only solution.

Secondly, to many minds there appears to be an equally great difficulty in the origin by saltation of complex adaptive structures, such as the eye. I shall not analyze this difficulty, but merely point to it and to the first one mentioned, as having had the practical effect of keeping many investigators persistently at work looking for something besides saltations as a basis for evolution; looking for hereditary changes that would permit a continuity in transformation. Some have been searching in the complex phenomena of biparental inheritance; here Castle is to be first named, and in a later lecture you will hear of the views to which he has been led. Others, like Prof. H. F. Osborn, have been searching from this point of view the paleontological records. Others of us have taken up the problem in uniparental reproduction; it is here that my own work falls, and of this I will for a moment speak.

Where reproduction is from a single parent we meet the problem of inheritance and variation in its simplest form; for

there is nothing which complicates genetic problems so enormously as does the continual mixing of diverse stocks in biparental inheritance. In uniparental reproduction we have but one genotype to deal with; we can be certain that no hereditary characters are introduced from outside that genotype.

To hope for results on the problem in which we are interested, we must resolve to carry on a sort of second degree research, as it were. That is, we must accept as a foundation the facts before discovered, as to the make-up of the species out of a great number of diverse stocks; as to the usual effects of selection being nothing save the isolation of such preexisting stocks. What we must do is to take a single such stock—choosing an organism that is most favorable for such work—then proceed to a most extensive and intensive study of heredity, of variation, and of the effects of selection for long periods within such a stock.

Such an organism, most favorable from all points of view, I found in the rhizopod *Difflugia corona*. It has numerous distinctive characters, all congenital; all inherited in a high degree; yet varying from parent to offspring also; none of these characters changed by growth or environmental action during the life of the individual.

Long continued work showed that a single strain of this animal, all derived by fission from a single parent, does differentiate gradually, with the passage of generations, into many hereditarily diverse strains. The important facts about the hereditary variations and their appearance are the following:

1. Hereditary variations arose in some few cases by rather large steps or "saltations."

2. But the immense majority of the hereditary variations were minute gradations. Variation is as continuous as can be detected.

3. Hereditary variation occurred in many different ways, in many diverse characters. There was no single line of variation followed exclusively, nor in the overwhelming majority of cases.

4. It gave rise to many diverse combinations of characters: large animals with long spines; small animals with long spines; large animals with short spines; small animals with short spines;

and so on, for other sorts of combinations of other characters. Any set of characters might vary independently of the rest.

5. The hereditary variations which arose were of just such a nature as to produce from a single strain the hereditarily different strains that are found in nature.[4]

I judge that if the intermediate strains were killed, the two most diverse strains found in nature might well be classed as different species, although the question of what a species is must be left to the judgment or fancy of the individual.

Such then were the results of my own studies as to the nature of hereditary variations and how they appear. How do these results compare with those found by other men? If we take a general survey, we find the following main classes of cases:

1. First, we have the mutations of Oenothera and its relatives: large transformations occurring suddenly. Here is evidently one of the most interesting fields of genetics, but I cannot feel, in view of many extraordinary phenomena in this group, that the bearing on the main problems of genetics is yet clear.

2. Second, we have a large miscellaneous collection of mutations observed in various classes of organisms: "bud variations," dropping out of unit factors, and the like—all definite saltations, but not genetically fully analyzed.

3. In Drosophila as studied by Morgan and his associates, we have the largest and most fully analyzed body of facts which we possess with respect to changes in hereditary character in any organism. The changes here are pictured as typical saltations; but of these I shall speak farther.

4. In paleontology, as the results are presented in recent papers by Osborn,[5] the evidence is for evolution by minute, continuous variations which follow a single definite trend.

5. Finally we have the work in biparental inheritance from Castle and his associates:[6] this, as interpreted by Castle, gives evidence for continuous variation, not following a single necessary trend, but guided by external selection.

[4] The full account of this work is given in JENNINGS, 1916. (See Bibliography.)

[5] See OSBORNE, 1912, 1915, 1916. (See Bibliography.)

[6] See CASTLE, 1915 *a*, 1916, 1916 *a*, 1916 *b*, 1917; CASTLE and PHILLIPS, 1914, etc. (See Bibliography.)

Furthermore, we discover in our survey that there are at least two well-marked controversies in flame at the present time:

First, we have the general controversy between, on the one hand, those who are mutationists and adherents of the strict genotype view; on the other hand, those who, like Castle, believe that we observe continuous hereditary variations in the progress of biparental reproduction. The mutationists attempt to show that the apparent gradual modification of characters observed in breeding is in reality a mere working out of Mendelian recombinations. Here we have contributions by Morgan (1916), Pearl (1916, 1917), MacDowell (1916), Hagedoorn (1914), and others on the one hand; while the full brunt of the attack is borne on the other side by Castle.

Second, we have a somewhat less lively controversy between the genotypic mutationists and the paleontological upholders of evolution by continuous variation. Echoes of this we find in recent publications by Osborn and by Morgan.

Now let us look briefly into the points at issue in the controversy between the "genotypic mutationsts" and the upholders of gradual change during biparental inheritance.

Castle finds that in rats he can, by selection, gradually increase or decrease the amount of color in the coat, passing by continuous stages from one extreme to the other. As to this, he holds two main points:

1. The change is an actual change in the hereditary characteristics of the stock; not a mere result of the recombination of Mendelian factors. This is the general and fundamental point at issue.

2. More specifically, he holds it to be an actual change in a single unit factor; this single factor changes its grade in a continuous and quantitative manner.

On the other side, the critics of these views maintain that the changes shown are not actual alterations in the hereditary constitution at all, but are mere results of the recombinations of Mendelian factors. And specifically, they find a complete explanation of such results as those of Castle in the hypothesis of *multiple modifying factors.*

The method in which these modifying factors are conceived to operate is doubtless familiar to you: their application to Castle's work with selection in rats will serve as an example. There is conceived to be a single "main factor" which determines whether the "hooded pattern" shall or shall not be present. In addition to this there are a considerable number of "modifying factors" which, when the "hooded pattern" is present, increase or decrease the extent of pigmentation. When many of the positive factors of this sort are present, the rat's coat has much pigment; when fewer are present the extent of pigment is less, and so on. The process of changing the extent of pigmentation by selection consists, according to this view, merely in making diverse combinations of these factors, by proper crosses.

This same explanation is applied to a great variety of cases. Castle had carried the war into the enemy's country by predicting (or at least suggesting) that the so-called unit characters in Drosophila would be found to be modifiable through selection.[7] Later research by MacDowell (1915), Zeleny and Mattoon (1915), Reeves (1916), Morgan (1917), and Sturtevant (1917) actually verified this prediction; it has indeed been found that the Drosophila mutations can be modified by selection. Again the mutationists counter the blow with their explanation of multiple modifying factors, which are segregated in the process of selection; and they give some real evidence that such is actually the case.

Now, into the merits of that particular question, as to whether the apparent effects of selection are really due to modifying factors in the manner set forth, I do not propose to enter. Castle maintains that they are not, and I doubt not that he will show you reason for that point of view. At this point my own discussion will diverge from what I judge that he will be likely to give. What I am going to do is to abandon the ground that Castle would defend, proceed directly into the territory of the enemy, accept the conditions met there, then see where we come out in relation to the nature of variation, the effects of selection, and the method of evolution.

[7] See Castle, 1915, p. 39. (See Bibliography.)

In no other organism have heritable variations been studied so thoroughly as in Drosophila, and no other body of men have been more thoroughgoing upholders of mutationism and of the multiple factor explanation of the effects of selection, than the students of Drosophila—Morgan, Sturtevant, Bridges, Dexter, Muller, MacDowell, and the others. We may therefore turn to the evidence from Drosophila with confidence that it will be presented with fairness to the mutationist point of view. We shall first ask (1) what we learn from the work on Drosophila as to the possibility of finding finely graded variations in a single unit character. Next we shall inquire (2) as to the relation of the assumed modifying factors to changes in hereditary constitution; to the nature of the effects of selection.

1. First, then, what are the facts as to numerous finely graded variations in a single unit factor? Here we have certain remarkable data as to the eye-color of Drosophila; data that are of great interest with relation to the nature of evolutionary change. This fruit fly has normally a red eye. Some years ago a variation occurred by which the eye lost its color, becoming white, a typical mutation. Somewhat later, another variation came, by which the eye color became eosin. By those wonderfully ingenious methods which the advanced state of knowledge of the genetics of Drosophila have made possible, it was determined that the mutations white and eosin are due to changes in a particular part of a particular chromosome, namely, of the so-called X-chromosome, or chromosome I. And further, it was discovered that the two colors are due to different conditions of the same *locus* of the chromosome; in other words, they represent two different variations of the same unit. Moreover, the normal red color represents a third condition of that same unit.

Somewhat later a fourth condition of this same unit was found, giving a color which lies nearer the red, between the red and eosin; this new color was called cherry. So we have four grades or conditions of this single unit character.

And now, with the minute attention paid to the distinction of these grades of eye color, new grades begin to come fast. In the November number of *Genetics*, Hyde (1916), adds two new grades,

one called "blood," near the extreme red end of the series, the other, called "tinged," near the extreme white end; in fact, from the descriptions it requires careful examination to distinguish these two from red and white, respectively. Thus we have now six grades of this unit. And in the same number of the same journal, Safir (1916) adds another intermediate grade, lying between "tinged" and esoin; this he calls "buff." All these seven grades are diverse conditions of the single unit factor, having its locus in a certain definite spot in the X-chromosome. Such diverse conditions of a single actor are known as multiple allelomorphs.

So, up to date we know from the mutationists' own studies of Drosophila that a single unit factor presents seven gradations of color between white and red, each gradation heritable in the usual Mendelian manner. These grades are the following: (1) Red; (2) blood; (3) cherry; (4) eosin; (5) buff; (6) tinged; (7) white.

Three of these grades have been discovered in the ast five months. It would not require a bold prophet to predict that as the years pass we shall come to know more of these gradations, till all detectible differences of shade have been distinguished, and each shown to be inherited as a Mendelian unit. Considering that the work on Drosophila has been going on only about seven or eight years, this is remarkable progress toward a demonstration that a single unit factor can present as many grades as can be distinguished; that the grades may give a pragmatically continuous series. The extreme selectionist asks only a little more than this.

Besides showing that a unit factor may thus exist in numerous minutely differing grades, this case shows that a heritable variation may occur so small as to be barely detectible. Although the variations do not usually occur in this way, the case presents the conditions which would allow of a gradual transition from one extreme to the other, by means of numerous intermediate conditions. In a population in which were occurring such minute changes as are here shown to be possible, we could get by selection such a continuous series of gradations as Castle describes in

his rats. The difference in the two cases is, that in Drosophila variations which are large steps occur as well as do the small ones; and that, according to Castle's conception of the matter, such minute heritable variations occur more frequently in the rat than in Drosophila. But on the showing of the students of Drosophila, there is scarcely any other difference in principle between what happens in Drosophila and what Castle believes to happen in the rat.

2. But as we have seen, the mutationists reject the view that the changes in the coat color of the rat are due to alterations in a single unit factor; they explain this and other cases of the effectiveness of selection on a single character by *multiple modifying factors*. Accepting again their contention, the question is shifted to the nature of such factors. What sort of things are these modifying factors? What is their relation to actual changes in the heritable constitution of organisms?

Our direct experimental knowledge of these "modifying factors" is scanty. What we have comes again mainly from the studies of Drosophila, so that we need not suspect it of being colored in such a way as to favor the selectionist point of view. We find data as to certain known modifying factors by one of the workers on Drosophila, Bridges (1916), in his recent important paper on non-disjunction of the chromosomes. And here we are taken back again to the series of eye colors, and indeed to one particular member of the series, the middle member, called eosin.[8] Bridges tells us that he found a factor whose only effect was to lighten the eosin color in a fly with eosin eyes; this factor indeed nearly or quite turns the eosin eye white. This factor Bridges calls "whiting." Another factor has the effect of lightening the eosin color a little less, giving a sort of cream color; this is called "cream *b*." A third factor dilutes the eosin color not so much; it is called "cream *a*." In addition to these, Bridges tells us that he has discovered *three other* diluters of the eosin color; we will call them the fourth, fifth, and sixth diluters. And finally Bridges tells us of another factor whose only effect

[8] BRIDGES, 1916, p. 148. (See Bibliography.)

is to modify eosin in the direction of a darker color: this factor he calls "dark." None of these factors has any effect save on eosin-eyed flies.

As you see, these things add tremendously to our gradations in eye color. We had already been furnished seven grades, from white to red; now we have seven secondary grades within a single one of these seven primary grades. Our list of gradations of eye color in Drosophila therefore takes now the following form:

Heritable grades of eye color, due to diverse variations of a single unit located in Chromosome I.	Variations that give modifications of the intensity of eosin, but are located in other chromosomes.
1. White	1. Whiting
2. Tinged	2. Cream b
3. Buff	3. Cream a
4. Eosin	4. Fourth diluter
5. Cherry	5. Fifth diluter
6. Blood	6. Sixth diluter
7. Red	7. Dark

Let us hasten to add that these seven new grades are not located in the same unit factor as are the seven primary ones; their loci are in other chromosomes (or possibly in other parts of the same chromosome).

Here again then we have minutely differing conditions of a single shade of color, brought about by seven modifying factors. Bridges makes the following remark concerning them:

> A remarkably close imitation of such a multiple factor case as that of Castle's hooded rats could be concocted with the chief gene eosin for reduced color, and these six diluters which by themselves produce no effect, but which carry the color of eosin through every dilution stage from the dark yellowish pink of the eosin female to a pure white.[9]

Now this is an extremely interesting statement, one that must arouse the keen interest of the student of the method of evolution. In Drosophila we could get the same sort of graded results that Castle does with his rats, only in Drosophila this is by

[9] Bridges, 1916, p. 149. (See Bibliography.)

means of multiple modifying factors, whereas Castle believes that in the rat it is by actual alterations of the hereditary constitution!

But what are these modifying factors? And here we come to the astonishing point. *These modifying factors are themselves alterations in the hereditary constitution.* Bridges leaves no doubt upon this point. He lists and describes them specifically as mutations; as actual changes in the hereditary material.

Where then is the difference in principle between the condition in Drosophila and that in the rat? In Drosophila there occur minute changes in the germinal material, such as to give, so far as our present imperfect knowledge goes, seven diverse grades of a color which is itself only one grade of another series of seven known grades. By means of these graded changes one could obtain, by the mutationist's own statement, the continuously graded results which selection actually gives. What more can the selectionist ask?

There are indeed certain differences in detail, in the notions entertained by the different investigators as to exactly *where* the changes occur. Castle believes that in the rat the changes occur all in one unit—in one chromosomal locus—giving a series like the primary series for eye color in Drosophila. The supporters of multiple modifying factors believe, on the other hand—if we are to accept Bridges' account of such factors as typical (and it is the only account we have)—they believe, I say, that these minute changes have occurred in *some other* part of the germinal material. But this difference is one of mere detail; it does not touch the fundamental question.

This fundamental question is as to the occurrence of these minute changes in the hereditary constitution, and as to the possibility of getting therefrom by selection various grades of a given external characteristic. In this, so far as I can see, there is complete agreement.

Now, doubtless, there is a further diversity in the mental processes of the two sets of men, in that the mutationist thinks of all these numerous grades as after all essentially discontinuous, as a series of steps so minute that the difference between one

and the next one is not detectible. His opponent, on the other hand, perhaps thinks of the series as actually continuous. But the difference is not a pragmatical one; when steps become so minute as to be beyond detection, the question whether they exist becomes metaphysical.

To put the case in brief, if the mutationists are to show that the existence of multiple modifying factors has any bearing on the general question of the effectiveness of selection, they must show that such factors are not themselves minute changes in the hereditary constitution. Not only have they made no attempt to do this, but in the only well-examined cases they state squarely that such factors are indeed alterations in the hereditary constitution.

For the inheritance of such factors as Mendelian units, of course absolutely nothing is required save that the location of the change is in a chromosome. No particular degree of magnitude; no unity of any other kind is required.

But there remains one point brought out by the mutationists which is of great importance to the student of the method of evolution. While they must admit, by their own account, that all these grades occur, so that a practically if not actually continuous series can be formed, they of course point out that the changes do not occur in a continuous series. In the eye of Drosophila variation may occur from red to white directly, without any transitional stages; or from any grade to any other; the continuous scale is obtained only by arranging the steps in order. Therefore, it is maintained, evolution may have occurred by such large steps, not by continuous gradations.[10] This is of course a matter deserving of serious consideration. But certain other points must be considered also. First, the very facts known for Drosophila show that there is nothing to prevent a passage from one extreme to the other by minute changes, just as is held to occur by the paleontologists and selectionists, although change by large steps occurs also. Secondly, in such cases as the eye color of Drosophila we are dealing with char-

[10] See particularly the discussion of this point in MORGAN, 1916, p. 7–27. (See Bibliography.)

acters that are already highly developed. We know for example, that this particular character is formed by the cooperation of many separate parts of diverse chromosomes; it is a highly complex product of evolution. Now, we find that one or another of these parts may suddenly cease to perform its function, so that the red color is not completely formed; there is a sudden change in it; or it may disappear entirely. But is this after all strong evidence that in the original production of this complex character with its numerous underlying functional parts, there was the same change by sudden large steps? Indeed, is it not rather true that such destructive changes in a fully formed character could not be expected to throw light on how that character was built up?

I am not unmindful of the fact that there are a few—but only a very few—cases in which there is indication of a positive addition by a definite step, as when the eosin color is produced in white-eyed stock. But here again the underlying apparatus has before had the power to produce eosin and other colors. The white color was due to the temporary suspension of function in parts of the chromosomal apparatus, and it may be doubted whether the restoration of this function throws light on the way the apparatus was first developed.

To sum up, it appears to me that the work on Drosophila is supplying a complete foundation for evolution through selection of minute gradations. The so-called "multiple allelomorphs" show that a single unit factor may thus exist in a great number of grades; the "multiple modifying factors" show that a visible character may be modified in the finest gradations by alterations in diverse parts of the germinal apparatus. The objections raised by the mutationists to gradual change through selection are breaking down as a result of the thoroughness of the mutationists' own studies. We have already gotten completely rid of the notion that the germinal changes consist only in the dropping out of complete units, or that they are bound to occur in large steps. If the recent rate of progress is maintained, when such an organism as Drosophila has been studied for fifty years, instead of eight or nine, there will be no conceivable gradation

of any character that will not have been detected. The only outstanding difficulty is the fact that large changes occur as well as small ones; this seems perhaps due to the fact that we are witnessing the disintegration of highly developed apparatus in place of its building up.

In all this, except the last point, the work on Drosophila is in agreement with my own observation of gradual variation in Difflugia; with Castle's similar results on the rat; and with the conclusions of paleontologists as to the gradual development of the characteristics of organisms in past ages.

But there is one point in the paleontological conclusions, as set forth in the recent papers by Osborn, which is not in agreement with the experimental and observational results on existing organisms; this I wish to notice briefly. Osborn sets forth that in following given stocks from earlier to later ages, characters arise from minutest beginnings, and pass by continuous gradations to the highly developed condition. This seems in agreement with experimental results, as I have tried here to set them forth. Further, according to Osborn, these developing characters do not show random variations in all directions, but follow a definite course, which might seem to have been in some way predetermined. And this is emphasized by the fact that the same sorts of characters (horns, for example) may arise independently, at different ages, in diverse branches of the same stock, and each follow in later ages the same definite course of development.

It would appear therefore from this that there must be some directing tendency, some inner necessity which drives a developing organ to follow a definite course. Evolution is characterized by Orthogenesis, as this phenomenon has sometimes been called.

Now it appears to me that we do not observe this in the present day experimental work; by selection we can move in more than one direction. I do not mean that the possible variations are not limited by the constitution of the varying organism; they certainly are. But there is no indication, so far as I can see, that the variations push in one determinate direction only.

Now, examining the paleontological summaries further as regards this (I refer to Osborn's papers), we find certain points

that appear to modify seriously, if they do not quite nullify, this conclusion that variations follow a determinate course.

First, we do find that diverse courses are followed by given characters, in diverse branches of a given group; this is particularly true of the characters of shape and proportion, which Osborn calls allometrons. I take it from the descriptions that this is likewise true at times for structural and numerical characters.

A second point which Osborn sets forth is deserving of particular attention. He states, in agreement with Waagen, that in any given geologic stratum, we do find, in addition to characteristics that are in the line of determinate descent, other variations from this line, which are of the sort that constitute what we call at the present time varieties; things that are like the diverse races of Difflugia in my own work. But, say Osborn and Waagen, there is a great difference in principle between these and the others, for those which are in the determinate line of progress persist into the next geologic stratum, while the mere varieties do not. The persistent changes were called by Waagen, mutations (in a sense somewhat diverse from that in which the word is used by de Vries).

Osborn expresses the opinion that these "varieties" may be merely non-heritable modifications.[11] But in our present geologic period we find just such diverging forms, in great number, and we find that their peculiarities *are* heritable; this I emphasized in the introductory part of the present discussion. There is then no reason for supposing that these variations were not heritable in earlier geologic periods; there must have been many races heritably diverse, just as there are now; and these are what Waagen called varieties.

Now since this is so, the only difference between Waagen's mutations and his varieties, is that, on looking backward at them, we find that the former persisted and the latter did not. But this tells us nothing whatever about why the latter did not. It is perfectly possible, so far as these facts go, that it was a

[11] OSBORN, 1915, p. 225. (See Bibliography.)

matter of selection by external conditions; many diverse stocks were present, on an equal footing; some were destroyed, others were not.

What ground then is there for saying that the development of given characters followed a definite course, as if predetermined? The conditions described are exactly what we should require to find if in past ages there were many varied stocks, some of which were preserved by the action of natural selection. Looking back over the series from a later age, we are bound of course to find it a continuous development. If the same characteristics were favorable in successive ages—and there is no reason why they should not be so—then the same sorts of variations would be preserved in those successive ages; a line of development once begun would be continued. And if the same sort of characters are favorable ones in different branches of a family, then similar characters may well arise and follow a similar course of development, in the diverse branches, as Osborn states they do. But at the same time many other heritable variations arise, that are not in the line of progress, and hence are not preserved through selection; these are precisely the "varieties" described by the paleontologists; the diverse races that I have described in Difflugia and Paramecium, and that are found to exist in all organisms. The conditions described by the paleontologists support strongly the theory of evolution by gradual change, but I cannot see that they tend to establish the view that variations show a tendency to follow a definite course, as if predetermined. The paleontologists appear rather to report precisely the conditions which we are bound to find if evolution occurs through the guidance of natural selection operating on a great number of diverse variations, the typical Darwinian scheme.

There is one other point which I wish I had time to take up, but I have not. I will merely attempt to state in a few words my impression of it. This is the point made by Bateson (1914) in his Presidential Address before the British Association, and farther developed by Davenport (1916) in a recent paper: the proposition, namely, that since practically all observed variations are cases of loss and disintegration, we are driven to suppose

that evolution has occurred by loss and disintegration. Davenport combines this idea with the theory that these disintegrating variations follow a definite course, predetermined in large measure by the constitution of the disintegrating material.

There are two points worth consideration in dealing with this theory. The first is one of fact; although it is true that many of the so-called mutations appear to be cases of loss and disintegration, yet there is no indication that this is the case in such effects of selection as have been described by Castle and myself; variations are not limited to any particular direction. Secondly, it appears to me that this conclusion—that because the variations we see are cases of loss and disintegration, therefore evolution must have occurred by loss and disintegration—it appears to me, I say, that this conclusion involves an error in logic, which makes it unworthy of serious consideration. The syllogism which it involves seems something as follows:

1. *Major premise.* Evolution has occurred by progress from the visibly less differentiated in structure to the visibly more differentiated in structure.

2. *Minor premise.* By observation we detect only the visibly less differentiated arising from the visibly more differentiated; we see only a process of decreasing the visible differentiation.

3. *Conclusion.* The visibly more differentiated must have arisen from the visibly less differentiated, by decrease in the visible differentiation of the latter.

The conclusion is absurd; it cannot be drawn save for the fact that while in the two premises we are talking of *visible* differentiation and disintegration, in the conclusion the ground is shifted to mean something entirely different—a sort of inner, invisible, purely theoretical kind of differentiation and simplicity and disintegration. By putting in the word *visible* all the way through, the absurdity is brought to light. All that we can legitimately conclude from the two premises is that we have not seen the process of evolution occurring. If we have seen nothing but loss and disintegration, this is indeed the conclusion that we must draw. But I believe that we cannot assert that this is all that we have seen.

To summarize then what I have obtained from experimental work combined with a survey of the work of others, the impression left is as follows:

1. Experimental and observational study reveals that organisms are composed of great numbers of diverse stocks differing heritably by minute degrees.

2. Sufficiently thorough study shows that minute heritable variations—so minute as to represent practically continuous gradations—occur in many organisms; some reproducing from a single parent others by biparental reproduction.

3. The same thing is reported from paleontological studies.

4. On careful examination we find even that the same thing is revealed by such mutationist work as that on Drosophila; single characters exist in so many grades due to minute alterations in the hereditary constitution as to form a practically continuous series.

5. It is *not* established that heritable changes must be sudden large steps; while these may occur, minute heritable changes are more frequent.

6. It is *not* established that heritable variations follow a definite course as if predetermined; they occur in many directions.

7. It is not established that all heritable changes are by disintegration; although many such do occur, they cannot be considered steps in progressive evolution from the visibly less complex to the visibly more complex.

Evolution according to the typical Darwinian scheme, through the occurrence of many small variations and their guidance by natural selection, is perfectly consistent with what experimental and paleontological studies show us; to me it appears more consistent with the data than does any other theory.

BIBLIOGRAPHY

Bateson, W., 1914. *Address of the President of the British Association for the Advancement of Science.* Science, **40**: 319–333. Bridges, C. B., 1916. *Non-disjunction as proof of the chromosome theory of heredity.* Genetics, 1: 1–52; 107–163. Castle, W. E., 1915. *Mr. Muller on the constancy of Mendelian characters.* Amer. Nat., **49**: 37–42. Castle, W. E., 1915 *a*. *Some experiments in mass selection.* Amer. Nat., **49**: 713–726. Castle, W. E., 1916. *Can selection cause genetic change?* Amer. Nat., **50**: 248–256. Castle, W. E., 1916 *a*. *Further studies of piebald rats and selection, with observations on gametic coupling.*

Carnegie Inst. Wash., Pub. 241, Part III: 161–192. CASTLE, W. E., 1916 b. *Genetics and Eugenics*. Cambridge. Pp. 353. CASTLE, W. E., 1917. *Piebald rats and multiple factors*. Amer. Nat., **51**: 102–114. CASTLE, W. E., and PHILLIPS, J. C., 1914. *Piebald rats and selection. An experimental test of the effectiveness of selection and of the theory of gametic purity in Mendelian crosses*. Carnegie Inst. Wash., Publ. 195. Pp. 56. DAVENPORT, C. B., 1916. *The form of evolutionary theory that modern genetical research seems to favor*. Amer. Nat., **50**: 449–465. HAGEDOORN, A. L. and Mrs. A. C., 1914. *Studies on variation and selection*. Zeitschr. f. ind. Abst. u. Vererb., **11**: 145–183. HAGEDOORN, A. L., and Mrs. A. C., 1917. *New light on blending and Mendelian inheritance*. Amer. Nat., **51**: 189–192. HYDE, R. R., 1916. *Two new members of a sex-linked multiple (sextuple) allelomorph system*. Genetics, **1**: 535–580. JENNINGS, H. S., 1908. *Heredity, variation and evolution in Protozoa. II. Heredity and variation of size and form in Paramecium, with studies of growth, environmental action and selection*. Proc. Amer. Philos. Soc., **47**: 393–546. JENNINGS, H. S., 1909. *Heredity and variation in the simplest organisms*. Amer. Nat., **43**: 321–337. JENNINGS, H. S., 1910. *Experimental evidence on the effectiveness of selection*. Amer. Nat., **44**: 136–145. JENNINGS, H. S., 1911. *Pure lines in the study of genetics in lower organisms*. Amer. Nat., **45**: 79–89. JENNINGS, H. S., 1916. *Heredity, variation and the results of selection in the uniparental reproduction of Difflugia corona*. Genetics, **1**: 407–534. MACDOWELL, E. C., 1915. *Bristle inheritance in Drosophila*. Journ. Exper. Zool., **19**: 61–97. 1916. MACDOWELL, E. C., *Piebald rats and multiple factors*. Amer. Nat., **50**: 719–742. MORGAN, T. H., 1916. *A critique of the theory of evolution*. Pp. 197. Princeton Univ. Press. MORGAN, T. H., 1917. *An examination of the so-called process of contamination of genes*. Anat. Record, **11**: 503–504. OSBORN, H. F., 1912. *The continuous origin of certain unit characters as observed by a palaeontologist*. Amer. Nat., **46**: 185–206, 249–278. OSBORNE, H. F., 1915. *Origin of single characters as observed in fossil and living animals and plants*. Amer. Nat., **49**: 193–239. OSBORN, H. F., 1916. *Origin and evolution of life upon the earth*. Scientific Monthly, **3**: 5–22; 170–190; 289–307; 313–334; 502–513; 601–614. PEARL, RAYMOND, 1915. *Seventeen years selection of a character showing sex-linked Mendelian inheritance*. Amer. Nat., **49**: 595–608. PEARL, RAYMOND, 1916. *Fecundity in the domestic fowl and the selection problem*. Amer. Nat., **50**: 89–105. PEARL, RAYMOND, 1917. *The selection problem*. Amer. Nat., **51**: 65–91. REEVES, EDNA M., 1916. *The inheritance of extra bristles in Drosophila melanogaster Meig*. Univ. Calif. Pub. Zool., **13**: 495–515. SAFIR, S. R., 1916. *Buff, a new allelomorph of white eye color in Drosophila*. Genetics, **1**: 584–590. STURTEVANT, A. H., 1917. *An analysis of the effect of selection on bristle number in a mutant race of Drosophila*. Anat. Record, **11**: 504. ZELENY, C. and MATTOON, E. W., 1915. *The effect of selection upon the "bar-eyes" mutant of Drosophila*. Journ. Exper. Zool., **19**: 515–529.

ETHNOLOGY.—*The Chitimacha of Bayou La Fourche, Louisiana.* DAVID I. BUSHNELL, JR. Bureau of American Ethnology.

Early in the eighteenth century, when the Chitimacha first became clearly known to the European colonists, they occupied two groups of settlements within their rather small territory just west of the mouth of the Mississippi. One group was in the vicinity of Bayou Teche and Grand Lake, on and near the site of the present town of Charenton, St. Mary parish, Louisiana, where some continue to dwell. The second group was

eastward, in the country adjacent to Bayou La Fourche, then known as the river of the Chitimacha. Many, if not all, of the latter removed from their ancient habitat during the years 1718 and 1719, but it is quite evident that other Indians soon occupied the old Chitimacha sites, and among the new arrivals were many Houma, and others from east of the Mississippi. Likewise, it is highly probable that some of the Chitimacha later found their way back to their old homes.[1]

At the present time several families living in Terrebonne and La Fourche parishes, near Bayou La Fourche, claim to be of Chitimacha descent, although they know some of their ancestors to have been Houma, and many have traces of European blood as well. On the following pages are given some of the mannerisms and customs of these people, as related by Abel Billiot, a man about sixty-five years of age, who is known as a Chitimacha, from the village of Point-au-chien in the southeastern part of Terrebonne parish, Louisiana.

HABITATIONS

The primitive form of habitation was constructed and occupied during the past ten years and, according to my informant, the last example was destroyed at the time of the great storm about eight years ago. The houses were built in the following manner: A slight excavation was made to correspond with the floor-space of the future structure. The wall was outlined by a row of posts about three of four inches in diameter and four feet or more in height, placed about two feet apart. Smaller flexible branches and saplings were interwoven between the upright posts. A low conical roof was formed of a frame covered with thick palmetto thatch. A hole was dug in which a quantity of clay and Spanish moss was mixed with water, this serving as plaster for the wall of wattle work. Clam and oyster shells were burned and the lime thus obtained was mixed with water and used to whitewash the inside wall of the

[1] Swanton has discussed this in *Indian tribes of the lower Mississippi Valley*, Bulletin 43, Bureau of American Ethnology, Washington, 1911.

house. On the day this work was to be done all the people of the village gathered, and the walls were completed between sunrise and sunset.[2] The structures were either round or square, and one, much larger than the others, is remembered to have served as a meeting place for the men of the village. The fires were made outside the house. Small shelters are said to have been made of skins.

FOOD

Much food was smoked and so preserved for future use. The method of smoking was this: Four poles were set up, extending between three and four feet above the surface. These were connected at the top by other poles or cords, and to the latter were attached the pieces of meat, the fish, the ducks, and all else that was to be smoked. The fire was made on the ground between the four stakes and no particular kind of wood was required. Many ducks were prepared in this manner, being first skinned, thoroughly cleaned and opened on the back. Everything was so well smoked as not to require more cooking before being eaten.

A hole was made in the ground (probably about the size of a bushel basket) and filled with clams or oysters. These were covered with a thin layer of sand or earth and a fire kindled above. After a certain time the covering was scraped away and the clams and oysters removed and eaten. Neither clams nor oysters are known to have been smoked, they being always plentiful and easily obtained.

Corn was grown and was prepared in various ways. Often it was pounded in a wooden mortar, then passed through a sieve to separate the fine from the coarse particles. The fine meal was mixed with water and allowed to remain over night during which time it would ferment and become sour. The following morning it would be boiled a little, and dried until "it would hold together," then it was eaten. This appears to

[2] This at once suggests a statement made by Adair in reference to the houses of the southern Indians: In one day, they build, daub with their tough mortar mixed with dry grass, and thoroughly finish, a good commodious house.

have been a favorite method of preparing the meal, the sour taste being relished. This was sometimes eaten with a sirup. Again, corn was allowed to ripen on the cob, and to become quite dry, before being shelled. Later the grains were parched by being mixed with hot ashes of a wood fire. The parched grains were then pounded in a wooden mortar, passed through a sieve, and eaten mixed with water.

Turtles were relished, and likewise their eggs, but the flesh was never smoked. Alligator eggs were eaten, but not the flesh unless other food was scarce. Salt was not used by the old people, and it is not cared for at the present time.

Berries and wild fruits are eaten when ripe, but are never dried.

DRESS AND PERSONAL DECORATION

The men, until quite recently, wore their hair long but did not plait it. The manner of cutting and shaping it is not remembered.

Formerly the hands, neck, and cheeks, were tattooed, the colors used being red and black. The former was derived from the juice of the giant rag weed (*Ambrosia trifida*); the latter was soot produced by burning yellow pine.

Small shells were perforated and strung as necklaces. Other shells were worked and pieces were fashioned into beads.

ARTS AND INDUSTRIES

Bowls, spoons, and paddles for stirring food were made of wood. The Chitimacha word for bowl is *Gah-mail'*. Mortars and pestles were made for use in preparing corn, and so forth.

A piece of hard stone is used with a steel to "strike fire," decayed dry wood, or a bit of old hide, being used to ignite with the spark.

The ancient, and still practiced, method of dressing skins as described by Abel Billiot is this: If possible, the skin as soon as removed, is stretched in a frame, or fastened to a flat surface, and in this position is allowed to dry. A frame is then constructed

of four poles, two being set in the ground, parallel and some three or four feet apart, the others being arranged in a horizontal position attached to the former. Within the rectangular space thus formed the skin is stretched and securily fastened. The frame holding the skin is not stood in a vertical position, but at an angle of about thirty degrees. A small fire of palmetto wood is made on the ground below it so that much smoke is produced. Some of the brain of the animal is then rubbed over the upper surface of the skin, which is thoroughly scraped with a chisel-shaped implement made of a piece of hard wood beveled at one end. After this surface has been sufficiently scraped the skin is turned over and the other side is treated with brains and rubbed and scraped in the same manner. During the entire process the skin is kept quite warm by the fire beneath it, and smoke is allowed to rise against it. After the scraping and rubbing, which has resulted in the removal of all hair and wool from one side and all particles of flesh from the other, the skin is quite soft and white. Sufficient oil, from the brain which has been rubbed into the skin, remains to keep it pliable. No other method of dressing skins is known to this man.[3]

Pottery vessels have been made and used within recent years, and are remembered by my informant. A blue clay found near his village was used for the purpose. Mixed with it naturally, was a sufficient quantity of sand, and neither sand nor pulverized shell was added. The clay having been obtained was worked in a wooden mortar, water being added to make a pasty mass. When the clay was of a proper consistency it was modelled into the desired vessel, which was then put in a shady place and allowed to remain two or three weeks before being baked. Tobacco pipes were, and are now, made in this manner. Before being placed in the fire, and after having become thoroughly dry, the vessel was smoothed by scraping with a shell or thin

[3] This method of preparing skins is more suggestive of the north than of the south, and differs greatly from the custom of the Choctaw who live just north of Lake Pontchartrain in St. Tammany parish. Bushnell, *The Choctaw of Bayou Lacomb, St. Tammany Parish, Louisiana.* Bulletin 48, Bureau of American Ethnology, Washington, pp. 11–12, 1909.

piece of hard wood, and any incised decorations were added at this time. Brown clay was not considered good for pottery making, and grease was never used to darken the ware. Spoons are made from cow horns.

Baskets are made from both split cane and the stems of palmetto, native dyes being used. Three colors are made and used by these people, yellow, red, and black, these added to the natural material giving them four shades to combine in their basket work. The yellow dye is derived from the roots of l'anze, which is known locally as paciance. This is a dock, probably *Rumex crispus* L. The root is crushed and pounded while fresh and is not allowed to become dry. The crushed roots are then placed in a kettle of water and allowed to boil. The split cane is also put in the kettle and soon becomes a brilliant yellow. If a red is desired the material is first dyed yellow, as stated, and is then removed from the kettle and allowed to remain over night in a protected spot, away from the wind. In the morning it is again put in the same liquid to which is added a small quantity of lime made by burning clam or oyster shells. It is again boiled and now turns red, caused by the action of the strong alkali. The shade of red may be governed by the density of the yellow dye, and by the length of time it remains in the alkali solution. Black dye is made by boiling the bark of the maple or live oak in water.

Cords or ropes are still made by twisting back moss. Only *black* moss will serve the purpose. A quantity is obtained and two persons work with it, twisting in opposite directions. After the cord is some twenty or thirty feet in length it is doubled and again twisted, this time very tightly.

Dugouts or pirogues are made of a single log of cypress. Other woods are sometimes used, but cypress is the favorite. Light canoes were formerly made by covering a frame of wood with skins or bark.

HUNTING AND FISHING

Blowguns were used in hunting small game and birds. They were made of pieces of cane from 5 to 7 feet in length.

Formerly the cane was split, the joints hollowed out and the inside smoothed, then the two pieces were bound together. More recently a piece of wire has been used to burn the joints. The darts were wrapped for a distance of about two inches with cotton or frayed cloth. Bows and arrows were used by the "old people," but not since they have been able to obtain guns and powder from the whites. Fish are secured by spearing them from a dugout, usually when the sun is shining brightly. Traps for catching fish are unknown to my informant, but nets are known to have been used.

Little could be learned respecting the social culture of these people, the native names of people and places having been forgotten. The myths and legends are no longer remembered, although several very old persons, now living east of the bayou near the coast, may retain some knowledge of their ancient tribal organization. All will soon be lost.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*The Cleveland Gas Field, Cuyahoga County, Ohio, with a study of rock pressure.* G. SHERBURNE ROGERS. U. S. Geological Survey Bulletin 661–A. Pp. 68, with 2 plates and 13 figures. 1917.

Most of the wells in the Cleveland gas field, which is located in the westerly suburbs of the City of Cleveland, are from 2500 to 2900 feet deep and draw their supplies from the so-called Clinton sand. The structure of the region is, broadly speaking, monoclinal, the formations outcropping in the western part of Ohio and dipping to the east beneath the great Appalachian Coal Basin. The Clinton sand itself does not outcrop, however, but feathers out in the central part of the state, and the Cleveland field and other important oil and gas fields to the south occupy a belt along the upper or thinning edge of the sand. The accumulation of the gas at Cleveland has been influenced also by structural considerations, the field being roughly coincident with a broad gentle bulge or nose on the monoclinal slope, and has been affected locally by the porosity or texture of the sand.

Owing to the very rapid growth of the field which was started in 1912, and which in 1915 contributed about 40 per cent of the Ohio production, the records of pressure and production decline are unusually complete and afford an interesting study. It appears that in any large group of wells there is a fairly close average relation between rock pressure and production. Hence by studying the pressure decline in any group it is possible to predict in advance of drilling the probable flow or volume of a new well in that group. If desired, the estimate may be evaluated according to the theory of probability and the number of chances in a hundred that the flow will not exceed a given figure may be calculated. Although the actual figures cited of course hold only in the Cleveland field the principles discussed should be applicable in many areas. G. S. R.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 316th meeting was held at the Cosmos Club, February 28, 1917.

INFORMAL COMMUNICATIONS

FRANK J. KATZ: *Age of the Worcester phyllite.* (No abstract.)

REGULAR PROGRAM

R. V. A. MILLS and R. C. WELLS: *The evaporation of water at depth by natural gases.* During the production of petroleum and natural gas in the Appalachian fields the associated waters undergo a definite order of change in the proportions of their dissolved constituents. Along with other gases, carbon dioxide escapes from solution while calcium carbonate and ferrous carbonate are deposited in the wells and in the interstices of the oil and gas bearing rocks. Concentration is brought about by the removal of water as moisture in the escaping gases and at the same time salt is lost from solution. The composition of the salt deposit is approximately: NaCl 94 to 99.5 per cent, $MgCl_2$ 2.5 to 0 per cent, $CaCl_2$ 3.0 to 0 per cent, and $CaCO_3$ 0.5 to 0 per cent. The composition of this salt was found by analyses of salt deposits collected from oil and gas wells and gas line pressure regulators; and this composition agrees closely with the composition of the salt deposit that can be predicated from the changes in the composition of the waters during their concentration under known conditions of production. Some of the pressure regulators, in which gas pressures are reduced from line pressures to distributing pressures, are several miles distant from the wells from which gas is derived. Analyses of salt deposited in the wells and regulators bear a striking resemblance to analyses of salt from Louisiana salt domes and salt beds in New York, Michigan, and Kansas.

Comparisons of analyses of Appalachian oil-field waters from different stratigraphic horizons in the same localities indicate that salt of the same general composition has been lost from solution during natural concentration. The investigators are convinced that the evaporative action of natural gas has been an important geologic factor in the changes which many deep-seated waters have undergone. During geologic time enormous volumes of natural gas have passed

through the sediments, so that sea water, which was interstitially included in marine sediments, has probably undergone a like mode of concentration.

Judging from experimental results obtained with illuminating gas, methane should be no exception among gases in its capacity to take up and transmit moisture. The amount of moisture in a given volume of gas under any given conditions can be calculated from the vapor pressure of solutions of salt in water. Conditions favorable for the transmission of water as vapor in porous rocks may be created by the chemical production of gases, by the expansion of compressed gases, by the release of gases held in solution in oil or water by pressure, and by the vaporization of liquefied gases.

Salt and brines are commonly found near occurrences of gas and petroleum, so that gases may have been effective in the evaporation of the solutions which yielded the salt. In fact, salt domes may be the result of evaporation and crystallization brought about by the passage of expanding natural gas which has carried off moisture as vapor and possibly also has cooled the solutions from which salt was crystallized.

The great changes effected in the waters of the Appalachian fields during the production of oil and gas were explained in part by the mode of occurrence of oil-gas-water mixtures in this region of low dips. The occurrence of gas and oil overlying water was attributed in part to induced segregation brought about during movements through the pay sands after production was begun.

M. I. Goldman: *Results of the microscopic examination of some rocks from the oil fields of southeastern Ohio.* This is a preliminary study and the conclusions are therefore only tentative. The primary object of the investigation was to find any characters of the rocks that might bear on the distribution of oil in them. As the work progressed it appeared that, in addition, light might be thrown on some of the early stages of metamorphism and their relation to geologic conditions It was found impracticable to make determinations of pore space because, by the tearing out of soft minerals, and in other ways, holes are produced in grinding the thin section. The investigation was therefore limited to the study of epigenetic minerals. The following were recognized: *Quartz* as a secondary growth around the original grains and in continuous crystallographic orientation with them, was found in almost all not too argillaceous sandstones. The approach to quartzite was in general greatest in the deepest beds, though this factor was very variable. *Kaolinite* in fine crystalline aggregates filling the pore spaces. This is known as a common mineral in sandstones. *Calcite* and other carbonates. These seemed to be particularly abundant in older fields or fields in which wells were very numerous, thus indicating a relation to recent circulation of ground, waters resulting from the drilling. *Sulphides* (pyrite or marcasite) were scarce in this field and occurred mainly in the clays associated with carbonaceous matter, a common syngenetic relationship. It is significant, however, as illustrating the mineralogic

and chemical individuality of different fields that, outside of this field, in Ohio and Pennsylvania they are sometimes common in large aggregations in sandstones. *Chert* and *opal* growths are scarce and difficult to recognize, and received no special attention. *Micas* are probably the most significant of the secondary minerals. They are of various species and types and their differentiation from syngenetic micas is difficult, being based mainly on habit and distribution. These most require further study, but so far as can at present be stated their development seems to be, like that of the carbonates, related to circulation resulting from opening up of wells. There were some indications that the development of secondary quartz and sulphides might also be related to this feature.

A final interesting metamorphic character is incipient granulation, apparently by pressure and followed by recementing of sand grains in a few of the deepest beds, especially in one sample at a depth of 2230 feet.

Of the relation of oil to these factors nothing can as yet be said. The most porous, which are generally the purest and coarsest sandstones, naturally form the best reservoirs, but they are often barren. A dark brown stain, believed to be due to oil, is also found related to the occurrence of carbonaceous matter in some of the clays, a relationship well recognized in the oil shales of the west.

The 317th meeting was held at the Cosmos Club, March 14, 1917.

REGULAR PROGRAM

HARRY FIELDING REID: *The distribution of land and water on the earth.* (No abstract.) Discussed by EAKIN, UMPLEBY, and W. J. HUMPHREYS.

WILLIAM BOWIE: *Some evidences of isostasy.* The first exhaustive test of the theory of isostasy was made by Prof. John F. Hayford, about ten years ago, while he was in charge of the geodetic work of the United States Coast and Geodetic Survey. For this purpose he used the connected triangulation of the United States and the astronomic observations made at several hundred triangulation stations. His results were surprisingly convincing that isostasy existed to a remarkable degree.

The speaker reviewed briefly the evidences of isostasy, as given by the most recent investigations of the subject by the Coast and Geodetic Survey. In these investigations there were used 219 gravity stations in the United States, 42 in Canada, 73 in India, and 40 other stations, which were principally in Europe. The conclusion reached by the speaker was that isostasy, for areas as large as the United States, is perfect and that it is practically perfect for areas of a much smaller size; such, for instance, as the state of Texas, or an area even smaller.

It is impossible to tell, with our present data, whether the local deviations from normal gravity, called anomalies, are due to a lack of

isostatic compensation locally or whether they are due to abnormally heavy or light materials near the station but in the region below sea level. This local deviation from normal in the gravity may be due in part to an actual deviation from perfect isostasy and in part to the abnormal densities near the surface.

It is reasonably certain that the anomalies cannot be due entirely to the use of erroneous densities for the topography, that is, the material which is above sea level, nor to the method of distributing the compensation with respect to depth. The largest anomaly, which is 0.093 dyne, is at Seattle and this is the equivalent of 3000 feet of material of normal density. As a matter of fact, Seattle is located near the coast and that station has an elevation of only 74 meters. We must, therefore, conclude that the anomaly at this station is caused by conditions which exist below sea level.

It has been found, as a result of the investigations, that a regional distribution of compensation out to a distance of 58.8 kilometers from a station is just as probable as the local distribution of the compensation. It has also been found that a regional distribution out to a distance of about 167 kilometers from the station is not so probable as the regional distribution to the smaller distance mentioned above or as a local distribution. There is no relation between the gravity anomalies and the character of the topography. There is, however, a decided relation between the gravity anomalies and certain geological formations. There is a very strong tendency for gravity to be light and the anomalies negative for stations located on the Cenozoic formation and the opposite is true for stations on the pre-Cambrian formations.

If the compensation were assumed to be distributed uniformly with respect to depth, then the depth of compensation, as derived from gravity data alone, is 95 kilometers. This agrees fairly well with the depth obtained from deflections of the vertical, but there is no geodetic evidence that the compensation is distributed uniformly with respect to depth. It is possible that some other method of distribution is the true one but it is difficult or practically impossible ever to discover, at least from geodetic evidence, what the true method of distribution is.

In the other countries data as detailed as for the United States were not available, but such tests as could be made indicated that isostasy in them was about as perfect as in this country. It is hoped that geodesists in the other countries will reduce their gravity stations for topography and isostasy by the same method as that used by the United States Coast and Geodetic Survey or by a similar one in order that more exhaustive tests may be made of the isostatic condition throughout the world.

Discussed by WHITE.

DAVID WHITE: *Discussion of gravity anomalies from the stratigraphic standpoint.* (No abstract.) Discussed by WILLIAM BOWIE.

H. E. MERWIN, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 119th regular meeting of the Society was held in the Crystal Dining Room of the Ebbitt Hotel, Wednesday evening, March 14, 1917. Seventy-four members and sixty-five guests were present. Mr. T. H. Kearney, President of the Society, presided. Mr. A. S. Hitchcock, the retiring President, delivered an address on *Taxonomic botany and the Washington botanist.* A full text of this address appears elsewhere in this Journal.[1]

The 120th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club at 8.00 p.m., Tuesday, April 3, 1917; eighteen members and one guest present.

Under "Brief Notes" Dr. W. H. Evans showed a Lummière plate of a pineapple field in Hawaii, part of which had been sprayed with an 8 per cent solution of ferrous sulphate. The sprayed portion of the field was a deep green color and produced an excellent crop while the unsprayed portion was yellow or pale green and the crop practically a failure.

The regular program consisted of the following papers:

The control of the white pine blister rust: Haven Metcalf. (Illustrated with lantern slides.) The white pine blister rust apparently originated in Asia and spread into Europe upon *Pinus cembra.* When the white pine (*Pinus strobus*) was introduced into Europe it proved to be subject to the disease. The first record of importation of white pine transplants from Europe to the United States dates back only to 1899. The disease was first reported in America in 1906. Since that date enormous quantities of diseased nursery stock have been imported. The pathologists and foresters of New England and the Middle Atlantic States discouraged importation of white pine seedlings after June, 1909, and importations was made illegal in 1912.

The disease has spread more rapidly and posessed greater virulence in New England than it did in Europe. At first it was hoped the disease would prove to be only a disease of nursery stock but at several points in New England it is attacking large trees. Inspection of nursery stock for blister rust is largely futile since the rust often incubates in pine tissue for many years before becoming apparent by distorting the growth or by fruiting. According to Ravn this incubation period may be as long as 20 years. As alternate hosts the black currants, both wild and cultivated, are particularly subject to the disease, and in areas of general infection are reliable indicators of its presence. On Ribes the disease is generally prevalent throughout New England, which means that the actual infection of pine is much more general than is shown at present.

[1] 7: 251. 1917.

The control of the disease in America presents three separate problems: (1) In the territory west of the Mississippi river the disease is not known to occur. During the coming season an extensive survey will be made of these states to determine whether the disease is or is not present. If it has not been carried into this territory on nursery stock, there is little possibility of its getting in by natural means. If the disease should once become established under western forest conditions, its control would be hopeless. All 5-needle pines of this area, including the very valuable sugar pine and western white pine, are subject to the disease, and many species of wild Ribes are common. (2) In the states between the Mississippi and the Hudson River, there is an area about 30 miles square in Minnesota and Wisconsin, northeast of St. Paul, which is heavily infected. In Indiana, Ohio, Pennsylvania, and New Jersey the disease has been found in a few nurseries and plantations, and is now believed to have been eradicated. In New York it has been found in both nurseries and plantations, and largely eradicated. (3) In New England the infection is so general that the only hope of successful growing of white pine in the future lies in the elimination of the alternate host of the disease. Whether such elimination can be made at a sufficiently low cost to be profitable has not been determined. Probably in localities where Ribes occur sparsely, as in Connecticut and Rhode Island, a great deal can be accomplished.

Dr. Metcalf called attention to the larger problem of free trade in plant diseases and in insect pests. He questioned it as a sound national policy and doubted if the entire *importing* nursery business is worth as much to the country as the damage which it causes. Not a single plant disease or insect pest that has once become established in this country has been eradicated or is ever likely to be. No matter how well controlled, it remains in every case a permanent tax against our economic resources. To safeguard the country against further invasions is therefore most important.

Technique for the study of the white pine blister rust: R. H. Colley. (Illustrated with lantern slides.) The study of the blister rust requires a knowledge of the anatomy of the hosts and of the life history and morphology of the fungus itself, since cultural studies are necessarily confined to the host plants. The best available methods of killing, embedding, and sectioning are being employed in working out the relation of host and parasite. Flemming's killing solution followed by Haidenhain's iron alum-haematoxylin and a counter stain of lichtgrün or orange G have proved very satisfactory for both host and parasite in both the pine and the currant stages. For quick sectioning of doubtful specimens previous to diagnosis the freezing microtome has been very satisfactory. Excellent preparations can be cut, stained, and mounted in two hours. The most satisfactory stains seem to be safranin and lichtgrün. When correctly handled, the hyphae and haustoria of the rust are sufficiently characteristic to be of positive diagnostic value, even before spores are formed.

Some natural groups in aspergillus: CHARLES THOM. (Illustrated with cultures.) A large number of strains obtained in cultures of Aspergillus fall into a series of natural groups. In these groups certain general morphological and physiological characters prevail. The differences between the members of the groups are for the most part quantitative rather than qualitative. In the *Aspergillus niger* group, the amount or intensity of color varies markedly among the individuals, other characters remaining the same. Individuals with exactly the same color and morphology show markedly different physiological activities. The differences between these latter physiological forms is certainly as important as the mere difference in the amount of color secreted in the spore, which difference has been commonly accepted as a basis for specific description.

Another great group may be made of the forms giving the morphology of *Aspergillus flavus.* In this series again the same condition exists as noted in the *Aspergillus niger* group. *Aspergillus fumigatus* and *A. nidulans* form two closely related series of organisms.

Several similar series may be made but the point clearly brought out is that there is evidence of mutation among these forms in which a single morphological or physiological character appears to separate one strain from the typical strain of the series as at present described. Within each group differences are easily recognizable, some of which are determinable only by chemical or physiological means. The solution of the taxonomic difficulty offered is that each group shall be designated by the name of one of its well-known species excepting when particular strains have become important economically or physiologically, and must therefore receive some further form of identification and description.

H. L. SHANTZ, *Corresponding Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 569th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, April 7, 1917; called to order at 8 p.m. by President HAY; 45 persons in attendance.

Under the heading "Brief notes and exhibition of specimens" Dr. R. W. SHUFELDT exhibited lantern slides of living California quail, calling attention to their rapidly diminishing numbers. Dr. L. O. HOWARD called attention to a specimen that had lately come to his notice, the cocoon of a Cecropia moth containing moonstones. He expressed the opinion that they had been placed there by a thieving crow or bluejay. Mr. A. W. WETMORE stated in this connection that he has seen bluejays insert small acorns and kernels of corn into large cocoons.

The regular program consisted of two communications:

ALEXANDER WETMORE and FRANCIS HARPER: *A note on the hibernation of the mud-turtle.* The authors reported finding a specimen of *Kinosternon pennsylvanicum* shortly after it had left its underground

winter-quarters. The hole from which it had emerged was beneath a dense growth of green-briar in an old field, and about 50 yards from the nearest marsh. The burrow was 9½ inches deep, and was open save at the lower end, where the animal had apparently lain encased in a mass of mud. The actions and condition of the turtle after being placed in water were described in detail, and an account of a post-mortem examination of the viscera was given. Messrs. W. P. Hay, M. W. Lyon, Jr., and Wm. Palmer took part in the duscussion.

A. S. Hitchcock: *Botanizing in the Hawaiian Islands.* The speaker visited the Hawaiian Islands during five months of 1916. He said the trade winds deposit their moisture upon the eastern and northern mountains of all the islands, furnishing the conditions for rain forests in these regions. The lee side of the islands is dry even to aridity. An interesting feature of the wet areas at or near the summit of the ridges are the open bogs. These bogs are devoid of trees and large shrubs, but contain a variety of low shrubs and herbaceous plants. Many species form tussocks, or hemispherical masses, raised above the level of the bog. The most conspicuous of the tussocks is made by a sedge (*Oreobolus furcatus*, Mann). Three peculiar species of Panicum are tussock-formers (*Panicum monticola* Hillebr., *P. imbricatum* Hillebr., and *P. isachnoides* Munro). Owing to the extreme isolation of the islands, the flora is peculiar and interesting. The family Lobeliaceae is represented by about 100 species, belonging to about 6 genera. Many species are arboreous, forming trunks 10 to 20 feet or in a few cases as much as 40 feet high. The crown of foliage gives the aspect of a palm. The grasses, disregarding the introduced species, are not numerous, but several are peculiar. The genus Eragrostis is represented by numerous species. A rare species of Poa (*Poa siphonoglossa* Hack.) produces leafless rushlike stems, as much as 15 feet long. The talk was illustrated by maps, botanical specimens, and numerous lantern slide views of various features of the islands.

M. W. Lyon, Jr., *Recording Secretary.*

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, May 19: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, May 23: The Geological Society, at the Cosmos Club, at 8 p.m.

Saturday, May 26: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

L. W. B. Rees, Royal Flying Corps: *Some difficulties encountered by the military aviator.* 30 minutes.

W. R. Blair: *Aerology in aid of aeronautics.* (Illustrated.) 20 minutes.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh day of each month.

CONTENTS

ORIGINAL PAPERS

Page

Geology.—On the terms aphrolith and dermolith. T. A. JAGGAR....... 277

Genetics.—Observed changes in hereditary characters in relation to evolution. H. S. JENNINGS.................................... 281

Ethnology.—The Chitimacha of Bayou La Fourche, Louisiana. DAVID I. BUSHNELL, JR.. 302

ABSTRACTS

Geology... 308

PROCEEDINGS

The Geological Society of Washington............................ 309
The Botanical Society of Washington............................. 313
The Biological Society of Washington............................ 315

Vol. VII

No. 11

June 4, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII — JUNE 4, 1917 — No. 11

PHYSICS.—*A visibility equation derived from the Ives and Kingsbury new luminosity equation.* Paul D. Foote, University of Minnesota.

In a recent paper Ives and Kingsbury[1] have found that the simple expression $L = 24000 \text{ exp.} - 1/(0.00250 + 0.00003795\, \vartheta)$ quite closely represents the relation between the luminosity L of a black body and its absolute temperature ϑ. It is interesting to enquire what function of the wave length λ the visibility must be to satisfy this equation of luminosity. We have:

$$L = \int_0^\infty V\, J\, d\lambda = \int_0^\infty V(\lambda)\, c_1\, \lambda^{-5} e^{-\frac{c_2}{\lambda\vartheta}} d\lambda = A\, e^{-\frac{1}{a+b\vartheta}} \quad (1)$$

where $V(\lambda)$ represents the visibility, J = intensity as given by Wien's law, and the expression on the right is the new luminosity relation.

Equation (1) is a simple integral equation which may be readily solved for $V(\lambda)$. If one makes successively the substitutions $x = 1/\vartheta$, $ax_t + b = at$, $p = b/a$, $p' = p/a$, and

$$g(s) = 2\pi i\, e^{1/a} A^{-1} c_1 c_2^{-4}\, V(\lambda)\, s^3 e^{ps}, \text{ one obtains:}$$

$$h(t) = e^{p'/t} = \frac{1}{2\pi i}\int_0^\infty g(s)\, e^{-ts}\, ds \quad (2)$$

[1] Phys. Rev., 8: 325. 1916.

Equation (2) may be solved for $g(s)$ by using the reciprocal integral (3) derived by Pincherle,[2]

$$g(s) = \int_c e^{st} e^{p'/t}\, dt \tag{3}$$

the integral starting at $-\infty$ below the axis of reals, encircling all singularities in the finite complex plane and ending at $-\infty$ above the axis of reals. On performing this integration and expressing $g(s)$ in terms of $V(\lambda)$ one obtains:

$$V(\lambda) = R\, e^{-\frac{c_2 b}{a\lambda}} \sum_{n=0}^{\infty} \left(\frac{b\, c_2}{a^2}\right)^n \frac{\lambda^{4-n}}{\underline{|n}\ \underline{|n-1}} \tag{4}$$

$$\text{where } R = A\, e^{-\frac{1}{a}}\, c_1^{-1} \doteq \text{constant.}$$

If $c_2 = 14{,}350$ and the values of a and b obtained by Ives and Kingsbury are substituted in (4) the final visibility equation takes the form.

$$V(\lambda) = R\, e^{-\frac{217.8}{\lambda}}\, \lambda^4 \sum_{0}^{\infty} \left(\frac{87130}{\lambda}\right)^n \frac{1}{\underline{|n}\ \underline{|n-1}} \tag{5}$$

The series in (5) is of the form $\Sigma x^n / \underline{|n}\ \underline{|n-1}$ where x is over 100,000. The ordinary methods of making such a series more rapidly convergent, such as Euler's transformation, etc., do not appear to assist materially in the present instance, and it is not evident that (5) can be expressed in closed form. Accordingly unless (5) can be put in a rapidly convergent form its main interest is in the method of its derivation, this being the first example in which a visibility equation has been derived from a luminosity equation. The ordinary procedure is the converse of this.

[2] Mem. Accad. Sci. Ist. Bologna, IV, vol. 8.

GENETICS.—*The control of the sex ratio.*[1] OSCAR RIDDLE, Department of Experimental Evolution, Cold Spring Harbor, New York.

No better way to introduce a discussion of the present subject has occurred to me than to avail myself of the words—written less than three years ago—with which Professor Doncaster begins his very excellent book on *The Determination of Sex:*

> The question "Is it a boy or a girl?" is perhaps the first which is generally asked about the majority of mankind during the earliest hours of their independent existence; and the query "Will it be a boy or a girl?" must equally often be in the mind, even if it is less frequently expressed in words. This second question raises one of the most widely discussed problems of biology, that of the causes which determine whether any individual shall be male or female, and it suggests the still deeper question, "Why should there be male and female at all?" The problem of the nature and cause of Sex ranks in interest with that of the nature and origin of Life, and it may be that neither can be completely solved apart from the other. Notwithstanding the immense amount of brilliant speculation and research which has been devoted to the fundamental problem of Life, it must be admitted that hitherto no satisfactory solution has been found, and in some respects the question of Sex is equally obscure. Hardly any other problem has aroused so much speculation, and about few has there been such great divergence of opinion. In one direction, however, the last few years have seen a considerable advance, and we now know at least something of the causes which lead to the production of one or the other sex, although of the manner in which these causes act our ignorance is still profound.
>
> It is but a short step from the question "Is it a boy or a girl?" to the further question "Why is it a girl instead of a boy?" and yet until recently the answer to this latter question seemed hopelessly beyond our grasp, and even now, although some indications of an answer can be given, they do not touch the deeper problems of the real nature of sex. It is a remarkable thing that apart from the fundamental attributes of living matter—irritability, assimilation, growth, and so forth—no single character is so widely distributed as sex; it occurs in some form in every large group of animals and plants, from the highest to the lowest, and yet of its true nature and meaning we have hardly a suspicion. Other widely distributed characters have obvious functions; of the real function of sex we know nothing, and in the rare cases where it seems to have disappeared, the organism thrives to all

[1] A lecture delivered before the Washington Academy of Sciences, March 29, 1917.

appearance just as well without it. . . . . Sex, therefore, although it is almost universally found, cannot be said with certainty to be a necessary attribute of living things, and its real nature remains an apparently impenetrable mystery.

From the statements of this rather long quotation we shall have occasion, during the present hour, to dissent only from the impression that the problem of the nature of sex offers difficulties of a magnitude comparable with those touching the origin of life, and that its mysteries are apparently impenetrable.

Studies on the heredity of sex have indeed made great progress during the last fifteen years. These studies have been concerned with sex-linkage and with the so-called sex-chromosomes. Since Doncaster, whom I have quoted, is one of the foremost workers in both of these fields of study, it is particularly significant that, in his opinion, all of the results thus far obtained from breeding and cytology have thrown so little light on the real nature and meaning of sex, and that from further advances in these fields he apparently hopes for so little. For this reason—and another, namely that the relation of chromosomes to heredity and sex, have probably been extensively treated in other lectures of this series—you will, I trust, not now require a lengthy survey of the relations which the chromosomes are known to bear to sex, but will grant most of the present hour for an examination of the results obtained from studies of a quite different sort; namely, of experimental attempts to control the sex ratio, to learn the nature of sex, and to control the development of sex.

It is quite necessary, however, that all experimental studies on the control of the sex ratio should be carried out with the fullest recognition of the known *normal* association of the chromosome numbers—particularly of the sex-chromosomes—with sex, if the results of such studies are to be used toward a decision of the question whether sex itself has been reversed or controlled. The all-important question concerning abnormal or unusual sex ratios is, of course, the question of their meaning—Has a particular germ cell which had initial tendencies to produce one sex been experimentally forced to the production of the opposite sex? Or—a quite different thing—have the conditions of the

experiment decreased or suppressed the production, or hindered the union, or modified the chromosomal constitution, of one of the types of germ cell and left the other type normal and functional? These possibilities for accounting for abnormal sex-ratios certainly exist and they must be squarely met by decisive experiment. The facts from this sphere which we shall most need to bear in mind while examining our series of ratios are as follows:

1. Sperm and ovum are two kinds of sex cells in respect of their origin from the two contrasted sexes; but, beyond this, it is now clear that in some animals one and the same male produces spermatozoa of two kinds, and that these two kinds are not equal in their prospective sex value. Still other animal forms are known in which the female produces two kinds of eggs, having opposite prospective sex value. Most groups of insects and several mammals are known to produce two kinds of sperm, while in moths (Lepidoptera) and birds the dimorphism of the germs exists in the eggs.

2. In forms which reproduce in part parthenogenetically—such as the bee, gall fly, plant-louse, etc.—the sex is known to bear certain relations to chromosome number, or to maturation phenomena in the egg.[2]

3. In wide crosses among Echinoderms, Baltzer ('09) and Tennent ('12) have shown that when the cross is made in one of the two possible directions, some of the chromosomes proceeding from the sperms are eliminated and do not take part in embryo-formation. This type of chromosome behavior has been found, however, only in crosses of very widely separated forms.

Pure wild species of doves and pigeons have proved to be almost ideal material for obtaining highly abnormal sex-ratios, and for the analysis of the meaning or significance of the modi-

[2] Even if one fully concedes the "lethal factor" explanation which Morgan (Science, N. S. **36**: 718. 1912) gives for a particular ratio (1 ♂: 2 ♀) in Drosophila, a similar basis could not apply to most of the pigeon series, since here *every* egg formed in the ovary can be accounted for, and in numerous series *every* egg hatched. These same facts, together with the fact that it is the female pigeon that is heterogametic, exclude the action of "assortative mating" as a cause of the sex-ratios obtained in the pigeon.

fied ratios. And since it has now been shown (we shall here attempt to demonstrate the point) that a real reversal or control of sex has been effected in these forms, the large and dimorphic ova found generally in doves and pigeons have permitted new lines of investigation on the nature of sex itself. As a final result of these studies—a result that we may very briefly indicate in advance of the presentation of the data—we believe that it is now reasonably clear that the two sexes are in fact the

TABLE 1

On the Relation Between "Width of Cross" and the Sex Ratio

MATINGS	WIDTH OF CROSS	NO. ♂	NO. ♀	SEX-RATIO
Columba × orientalis	Families	15	1(?2)	15.00: 1 (or 7.50: 1)
Alba × orientalis (spring—before July 1)	Genera	28	10	2.80: 1
Alba × orientalis (average)	Genera	58	43	1.35: 1
Orientalis × alba	Genera	36	33	1.09: 1
Average reciprocal crosses	Genera			1.22: 1
Turtur × orientalis, average reciprocal crosses	Species	14	18	0.78: 1
Unrelated orientalis	Same species	36	34	1.06: 1
Inbred orientalis	Same species (−)	18	20	0.90: 1

expression of the rate of protoplasmic activity—of metabolism—pitched at two different heights or levels. For the pigeon world the data seem quite conclusive, and when we shall have reviewed a part of these data we will undertake to place before you the experimentally modified sex ratios obtained elsewhere among animals, in an attempt to show that this considerable body of evidence supplies further confirmation, and only confirmation, for the modifiability of sex, and for our conclusion that the male sex is an expression of metabolism at a higher level, the female sex of metabolism at a lower or more conservative level.

The work which first showed the remarkable suitability of the wild pigeons for the analysis of the sex-problem was done by the late Professor Whitman who devoted many years to the study of these forms. Whitman obtained indisputably a profound modification of the sex-ratio, and identified in a general way some factors associated with the modified ratios. Whether

TABLE 2

SEX RATIOS AND "WIDTH OF CROSS" AS REPORTED BY VARIOUS AUTHORS

AUTHOR	CROSS	= DIFFERENT	♂:♀
Buffon[a]	Goat × sheep	Species	7: 2
	Dog × wolf	Species (?)	3: 1
	Gold-finch × canary	Species	16: 3
Suchetet	Various[b]	Genera	74: 13
	Various[b]	Species	72: 18
	Tetrao	Species	40: 8
	Lagopus × Tetrao	Genera	13: 7
Phillips	Ducks	Races	46: 24
Guyer[c]	Guinea × chicken	Sub-fam.	6: 0
	Pheasant × chicken	Sub-fam.	12: 0
	Peafowl × chicken	Sub-fam.	2: 0
	Peafowl × peafowl	Genera	1: 0
	Pheasant × pheasant	Genera	14: 1
	Pheasant × pheasant	Species	12: 3

Totals: s. fam. 20.0: 0; gen. 4.9: 1; sp. 4.3: 1; rac. 1.9: 1

[a] Cited by Suchetet and by Guyer.
[b] As summarized by Guyer from Suchutet's studies on museum specimens.
[c] Guyer's figures refer not to breeding data, but to the specimens available in various museums (British, Paris, etc.).

the modified ratios signified a real control—a reversal—of sex could not at that time be definitely decided. But on this question he obtained three kinds of evidence, to be mentioned later, and all of these indicated true sex-reversal.

Whitman showed that "width of cross" in doves and pigeons is of first importance in determining sex ratios in hybrid pig-

TABLE 3

FERTILITY IN "FAMILY" AND "GENERIC" CROSSES

FAMILY CROSS			GENERIC CROSS		
Common × ring			Ring × turtle		
A1	6- 9-15	infert.	D1	4-27-07	*infert.*
A2	6-11-15	infert.	♂D2	4-29-07	hatch.
♂B1	6-23-15	*hatch.*	♂E1	6- 2-07	hatch.
♂B2	6-25-15	*hatch.*	♂E2	6- 4-07	hatch.
C1	7- 1-15	infert.	♀F1	7-14-07	hatch.
C2	7- 3-15	infert.	♀F2	7-16-07	hatch.
D1	7-28-15	infert.	♂G1	8-25-07	hatch.
D2	7-30-15	infert.	♀G2	8-27-07	hatch.
E1	8-13-15	infert.	♂A1	2-12-08	hatch.
E2	8-15-15	infert.	♀A2	2-14-08	hatch.
F1	9-10-15	infert.	♂B1	3-18-08	hatch.
♂F2	9-12-15	*hatch.*	♂B2	3-20-08	hatch.
G1	9-26-15	infert.	♀C1	4-17-08	hatch.
G2	9-28-15	infert.	♀C2	4-19-08	hatch.
H1	10-10-15	infert.	♀D1	5-23-08	hatch.
H2	10-12-15	infert.	♀D2	5-25-08	hatch.
I1	10-21-15	infert.	♀E1	6-26-08	hatch.
♂I2	10-23-15	*hatch.*	♀E2	6-28-08	hatch.
J1	11-15-15	infert.	♀F1	8- 9-08	hatch.
J2	11-17-15	infert.	♀F2	8-11-08	hatch.
K1	12-13-15	infert.	♀G1	9-20-08	hatch.
K2	12-15-15	infert.	♀G2	9-22-08	hatch.
L1	12-28-15	infert.	♂A1	3- 2-09	hatch.
L2	12-30-15	infert.[a]	♀A2	3- 4-09	hatch.

[a] All of the succeeding 64 eggs produced by this pair—under continued "overwork"—have been tested for fertility. Of these 62 were wholly infertile; the other two hatched (both are males).

eons and that the wider the cross the higher is the proportion of males. Family crosses produce, in nearly all matings, only male offspring. Generic crosses produce from their "stronger" germs—those of spring and early summer—nearly all males. If, however, the birds of such a generic cross be made to "overwork at reproduction," that is if their eggs are taken from them as soon as laid and given to other birds for incubation, then the same parents which in the spring threw all or nearly all male offspring may be made to produce all, or nearly all, female offspring in late summer and autumn. At the extreme end of the season eggs capable of little, then of no development, are often found in such series. As the parent birds grow older the time of appearance of females, and of eggs incapable of full development, is reached earlier and earlier in the summer or spring.

The relation of "width of cross" to the sex ratio in one of the many species (*Turtur orientalis*) with which he worked is summarized[3] in Table 1. Practically every gradation from the widest possible (family) cross to inbreeding shows a sex ratio in accordance with its position in the series.[4] The "family cross" shown in Table 3 has also produced only males.

In Table 2 I have grouped according to width of cross a number of sex ratios reported by various observers. Here again it is found that family crosses yield only male offspring (20 ♂ : 0 ♀); generic crosses a ratio of 4.9 ♂ : 1 ♀; specific crosses 4.3 : 1; racial crosses 1.9 : 1. The normal sex ratio, i.e., the ratio for any of these species mated to its own kind, is probably nearly 1 : 1 or at most not higher than 1.3 ♂ : 1 ♀. The method of collecting most of these data renders then objectionable as evidence on some important questions, and the numbers are small, but they certainly support the generalization that as the "width of the cross" is increased a relatively higher proportion

[3] The matings included in this table were continued by the present writer; both earlier and later work (to 1914) are included in the summary.

[4] The specific cross—*T. turtur* and *T. orientalis*—whose ratio (0.78 : 1) is a seeming exception is in reality not an exception. One of the females used in this cross had been previously "overworked" and threw nearly all females as a consequence. For complete data see C. O. WHITMAN, Posthumous Works, Vol. II, chap. 4. The Carnegie Institution of Washington. (In press.)

TABLE 4

BREEDING RECORDS—1914

(St. alba ♂ ×) ♀ St. risoria 641 (old); 1913 = 42 eggs.

Series 1

♀A1	1- 1	White 140	♀U1	7-28	White 144
♀A2	1- 3	White, dead 2-3	♀U2	7-30	White 151
1st (4) = 2.066 g. 2d (4) = 2.243 g.					
			♀V1	8-14	White 155
H1	4- 4	Inf. yolk = 1.995 g.	♂V2	8-16	Dark 169
H2	4- 6	Inf. yolk = 2.105 g.			
			♀WI	8-22	White 152
♀I1	4-12	White, killed 4-29	W2	8-24	Soft at pole
♀I2	4-14	White 158 (?2)			
			♀XI	8-30	White 161
♂J1	4-21	Dark, killed 2-25	♀X2	9- 1	White 145
♀J2	4-23	White 158			
			♂Y1	9- 9	Dark 161
♀K1	4-29	White 147	♀Y2	9-11	White, killed bef. 10-12
♀K2	5- 1	White 151			
			♀Z1	9-18	White
L1	5- 9	Broken	♀Z2	9-20	White, dead 10-26
?♂L2	5-11	Dark (disap.?)			
			♀AA1	9-26	White 141
♂M1	5-18	Dark 161 (?1)	♀AA2	9-28	White 146
♀M2	5-20	White 163			
			♀BB1	10- 7	White 150
♀N1	5-30	White 150	♀BB2	10- 9	White 144
♀N2	6- 1	White, killed with ext.			
			?♀CC1	10-17	Dark, dead 11-8
♂O1	6- 7	Dark 150	♀CC2	10-19	White, dead 11-10
♀O2	6- 9	White 150			
			♀DD1	10-26	White 130 (?1)
♂P1	8-18	Dark 149	♀DD2	10-28	White 162 (?2)
P2	8-20	Broken			
			♂EE1	11- 6	Dark 152
♀Q1	6-28	White 143	♀EE2	11- 8	White 143
♀Q2	6-30	White 137			
			♀FF1	11-16	White 166
♀R1	7- 4	White 154	FF2	11-18	Broken
♂R2	7- 6	Dark 162			
			♀GG	11-26	White dead 150
?♂S1	7-12	Dark, dead 7-29	♀HH1	12- 7	White
♀S2	7-14	White, dead 7-31	♂HH2	12- 9	Dark, dead 1-9-15
♀T1	7-20	White 140	♀II1	12-20	Dark, dead 11-6-15
♂T2	7-22	Dark 164	♀II2	12-22	White, 9 da. embr.

1st 17 = 5 ♂ : 12 ♀; 2nd 17 = 4 ♂ : 13 ♀; last 17 = 2 ♂ : 15 ♀

of males is produced. It may be noted in passing that this generalization touches the question of the nature of sexual difference; for, studies among the most diverse animals and plants have afforded evidences of the "increased vigor of hybrids," of what Darwin called the "good effects of crossing," and of what has been observed in Mendelian breeding as the "greater vigor of the heterozygote." The means of "increasing the vigor" of the offspring are, therefore, the very same means by which higher and higher proportions of males are obtained; and males, we have concluded from other studies, are characterized by a more active metabolism than that found in females.

A glance at Table 3 will assist in making clear some of the advantages which the pigeons afford in the analysis of sex ratios. First, examining the details of the "family cross"—it is an exceptionally bad history with almost complete infertility—we note that only males are produced, but that a very great number of eggs failed completely to develop. It might be contended that in such a series only the male-producing eggs are fertilized, and for this reason only males are produced. We may fully grant the point; though attention should be directed to the fact that if this were the *whole of the story* it is rather remarkable that only 4 eggs of the 18 here shown (6 of 88 in the entire series) were fertilized, since it can be proved in any similar series that at least half of the 18 eggs (also half of the 88) were male-producing eggs. And a further point of interest is that while 4 of the first 18 eggs were fertile only 2 of the last 70 eggs—produced under overwork, or crowded reproduction—were fertile. But to recur to the original point—the pigeon in any event affords an opportunity to study the *total production* of the animal's ovary; and this particular animal's ovary contains all of the sexually differentiated germs.

In the second section of Table 3 are given the details of a *generic* cross, a cross of less widely departed forms than in the preceding case. In these crosses practically every egg can be hatched and the sex of the resulting offspring learned. This was done in 23 of the 24 eggs here recorded. This particular record is one of the many made by Professor Whitman from which he

TABLE 5

BREEDING RECORDS—1914

(St. alba ♂ ×) ♀ St. risoria 647 (young); 1913 = 18 eggs

Series 2

A1	1- 9	Wt. yolk = 1.515 g.
A2	1-11	Wt. yolk = 1.595 g.
B1	1-28	Wt. yolk = 1.590 g.
B2	1-30	Wt. yolk = 1.685 g.
C1	2- 8	Inf. yolk = 1.445 g.
C2	2-10	Broken
♂D1	3- 5	Dark 8-da. embr.
♀D2	3- 7	White
♂E1	3-19	Dark 167
♂E2	3-21	Dark 180
♀F1	3-29	White 154
♂F2	3-31	Dark 190
♂G1	4- 8	Dark, killed 5-6
♀G2	4-10	White, killed 5-3
♀H1	4-16	White 153
♀H2	4-18	White 153
♂I1	4-25	Dark 169
♀I2	4-27	White 154
J1	5- 5	3-da. embr. killed
J2	5- 7	3-da. embr. killed
♂K1	5-14	Dark 169
♀K2	5-16	White 158
♂L1	5-25	Dark 179
♀L2	5-27	White 164
♂M1	6- 3	Dark 169
♀M2	6- 5	White 11-da. embr.
♂N1	6-13	Dark 165
♀N2	6-15	White 150
♂O1	6-22	Dark, killed 7-13
O2	6-24	Wt. yolk = 1.968

♀P1	7- 1	White 150
♀P2	7- 3	White 15-da. embr.
♀Q1	7- 9	White 148
♂Q2	7-11	Dark 164
♀R1	7-22	White 152
♂R2	7-24	Dark 172
?♀S1	8- 3	White 13-da. embr.
S2	8- 5	Broken 3-da. embr.
♂T1	8-12	Dark 174
♀T2	8-14	White 164
U	8-20	Yolk = 1.490 g.
V1	9- 6	"Blood circle"
♂V2	9- 8	Dark 170
?♂W1	9-19	Dark, dead 10-16
♀W2	9-21	White, dead 10-14
♂X1	9-30	Dark, dead 10-19
♀X2	10- 2	White 145
Y1	10-29	Inf. yolk = 1.845 g
♀Y2	10-31	White 15-da. embr.
Z1	12-27	No dev. yolk = 1.870 g.
Z2	12-29	No dev. yolk = 1.925 g.

♀641 = (170 g.) (♂ 170 g.)
♂'s (5) from 1st = 155 g. ♀'s (13) = 149 g.
♂'s (3) from 2nd = 165 g. ♀'s (11) = 150 g.

♀647 = (166 g.) (♂165 g.)
♂'s (7) from 1st = 170 g. ♀'s (5) = 151 g.
♂'s (5) from 2nd = 175 g. ♀'s (6) = 158 gr.

1st 18 = 9 ♂ : 9; ♀ 2nd 18 = 8 ♂ : 10 ♀; (1915 = 11 ♂ : 21 ♀)

learned the following facts: (1) Generic crosses, when not permitted to lay many eggs, produce mostly or only males. (2) Such pairs, when made to lay many eggs (crowded reproduction) produce males predominantly from their earlier, stronger eggs, and predominantly or only females from the later eggs laid under stress of overwork. (3) From the eggs of pure wild species the first egg of the pair or clutch more often hatches a male; the second egg of the pair more often produces a female.

These generic crosses, then, show practically full fertility and exclude the possibility of accounting for the abnormal sex ratio of either spring or autumn by any "assortative mating" of germs, since the sperms by hypothesis are all alike,[5] and *all* of the ova are fertilized and the resulting sex of all is known.

From series of eggs produced by generic crosses, under "overwork" it is therefore practicable to select a certain number of eggs from near the first and from near the last of the season, and have fair assurance that (in this type of mating) most if not all of the earlier lot are prospectively male-producing, and most or all of the later lot are female-producing eggs. It was this possibility that enlisted my own first efforts in the study of sex. And, since a single individual ovum or yolk of the pigeon is large enough to permit a chemical analysis—our first study was to determine whether possible chemical differences between the male and female-producing ova exist and are discoverable. The first analyses of the pigeon's ova were made in April, 1911, and the work has been carried on continuously since that time. Nearly 900 individual yolks have now been analyzed. Among these are represented the eggs of several pure species, and of many kinds of hybrids. The records for the chemical composition of the egg-yolks of a considerable number of individual females is now complete for five consecutive years. Altogether, these studies, and the supplementary ones which developed out of them or along with them, have brought to light a number of facts which I can here only briefly sketch.

Before considering the results of the analyses it may be well to make clear the nature of a difference which appeared as soon

[5] It is certain that the ova are sexually dimorphic.

as my first lots of yolk samples were placed on the balances for the preliminary weighings. The balances alone and at once showed that the *mass* of the yolk of the first egg of nearly all pairs of eggs (from pure species) was less by from (usually) 9 per cent to 15 per cent than the mass of the yolk of the second

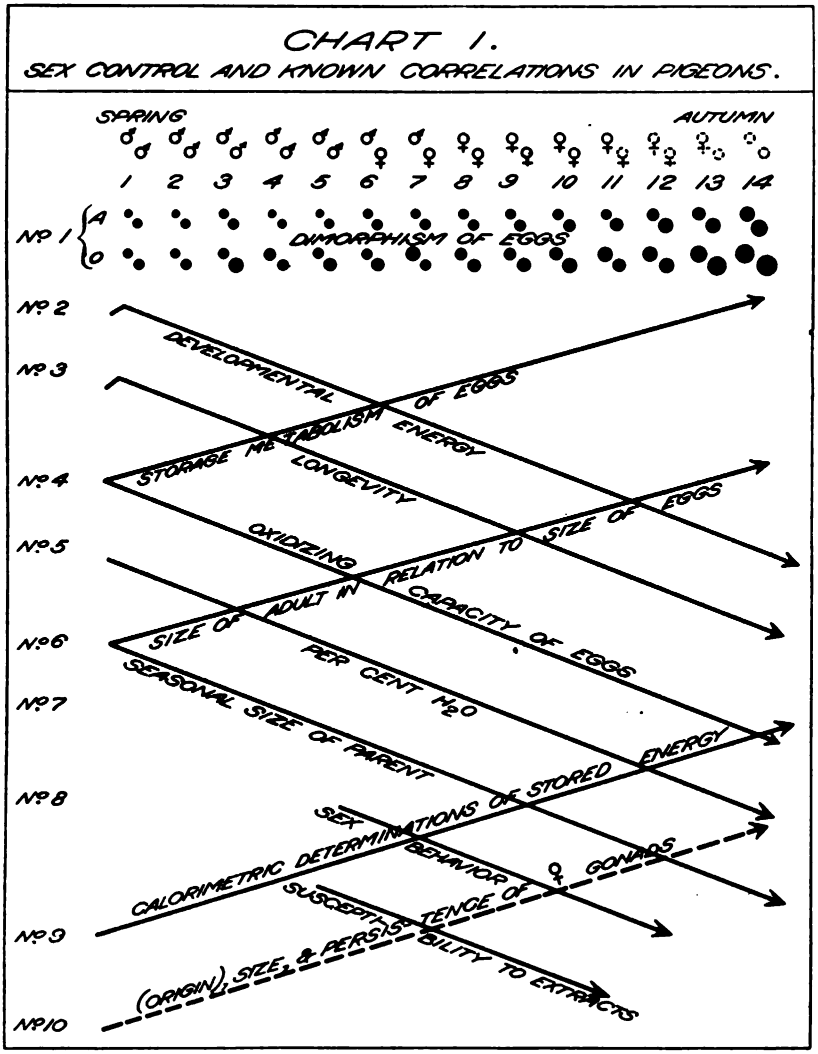
TABLE 6

WEIGHT OF ENTIRE EGGS, AND OF YOLKS, 1913–1915 OF ♀ 641 and ♀ 647

YEAR	TOTAL EGGS PRODUCED	EGGS. ord. no. wt. + hr.[a]	YOLKS no. wt. + hr.	SEX ♂ : ♀
		♀ 641 (older)		
1913	(42)	1st (19) = *8.532* + 25½ 2nd (19) = *9.221* + 16	(5) *1.903* + 15½ (6) *2.153* + 20½	9 ♂: 8 ♀: 1 ♂ ♀
1914	(67)	1st (30) = *8.627* + 6½ 2nd (31) = *9.275* + 1½	(4) *2.032* + 139 (5) *2.219* + 106	11 ♂: 40 ♀
1915	(16)	1st (7) = *8.584* + 6 2nd (7) = *9.290* + 1	....	6 ♂: 8 ♀ (*all early*)
		♀ 641 dead 4-17-15	Total............	26 ♂: 56 ♀
		♀ 647 (younger)		
1913	(18)	1st (6) = *7.246* + 6 2nd (5) = *8.062* + 2	(2) *1.482* + 11 (2) *1.535* + 3½	1 ♂: 6 ♀ (*all late*)
1914	(51)	1st (25) = *7.478* + 9 2nd (24) = *8.403* + 4	(5) *1.653* + 70 (4) *1.793* + 59	17 ♂: 19 ♀
1915	(45)	1st (22) = *7.624* + 11 2nd (22) = *8.481* + 3	(1) *1.715* + 166 (1) *1.970* + 171	11 ♂: 21 ♀ 1 (?)
		♀ 647 dead 2-16-16	Total............	29 ♂: 46 ♀

[a] The entire egg *loses* weight on standing; the yolk *gains* weight on standing.

egg of the pair. There were occasional reversals of this relation and also occasional pairs with quite nearly equivalent weight. In the eggs produced by hybrids this relation did not obtain at all. Illustrations of these differences in weight between the egg-yolks of first and second egg of the clutch may be seen in any of



Nº 1 SHOWS COMPARATIVE SIZE OF EGGS OF ALBA (A) AND ORIENTALIS (O).

TABLE 7

SUMMARY OF PARALLEL BREEDING AND CHEMICAL STUDIES ON THE EGGS OF ♀ *T. orientalis* No. 500 × *St. alba* No. 410—FOR THE YEAR 1912

DATE	AN'L'S OR INC.	WT. OF YOLK	ALC. SOLUBLE	RESULT					
				Phosphatide	Proteins	Ext.	Ash	H_2O	Energy total
4-13			Broken when found						
4-15			Broken when found						
5-26	159	2.330	72.65	18.32	25.44	5.28	4.85	57.01	7405
5-28	160	2.660	72.45	17.54	25.63	5.25	2.62	54.82	8990
6- 7	Inc.		Only one egg laid.			......	......	......	Dark ♂
6-15	Inc.		......	......	......	......	......	......	Dark ♂
6-17	Inc.		"Very large egg".			......	......	......	White ♀
6-24	Inc.		......	......	......	......	......	......	No dev.
6-26	Inc.		......	......	......	......	......	......	Dark ♂
7- 3	186	2.026	71.95	16.49	26.00	3.63	2.43	56.05	6714
7- 5	187	2.330	72.27	19.18	26.55	3.75	1.93	55.22	7881
7-15	Inc.		......	......	......	......	......	......	Dark ♂
7-17	Inc.		......	......	......	......	......	......	Dark ♂
7-23	192	2.422	72.42	17.82	25.88	3.82	1.80	55.84	8061
7-25	193	2.720	72.45	18.88	25.96	3.86	1.81	55.33	9296
8- 2	Inc.		......	......	......	......	......	......	Dark ♂
8- 4	Inc.		......	......	......	......	......	......	Dark ♂
8-13	Inc.		......	......	......	......	......	......	No. dev.
8-15	Inc.		......	......	......	......	......	......	Dark ♂
8-23	Inc.		......	......	......	......	......	......	No dev.
8-25	Inc.		......	......	......	......	......	......	White ♀
9-15	Inc.		......	......	......	......	......	......	White ♀
9-17	Inc.		......	......	......	......	......	......	White ♀
11-29	259	2.700	73.17	21.40	[a]25.23	......	......	55.52	9323
12- 1	260	2.715	73.02	21.63	[a]25.38	......	......	55.39	9383

[a] Calculated.

the appended tables in which yolk weights are given (Tables 4, 5, 6, 7, 8).

Other facts concerning the yolk weights which soon came to light were, that the yolks from an individual bird become larger in the autumn, particularly if the bird is made to lay numerous eggs (i.e., overworked) during the season. A schematic representation of the dimorphism of the ova, and of their increase in size from spring to autumn is shown (under 1) in Chart 1. A further fact of kindred nature was learned when the study was extended over a period of years, namely that the egg-yolks of an individual bird tend to become larger as the bird grows older; the yolks of the spring, however, are usually smaller than those of the previous autumn, though larger than those of the previous spring (Table 6). These facts are now established by accurate weighings of more than 12,000 yolks, freed and separated from their surrounding shell and albumen.

The details of the chemical analyses of one series of eggs obtained in 1912 are given in Table 7. These details we need not here consider, but it will be observed that we find larger amounts of the various chemical fractions (excepting water) in the female-producing egg than in the male-producing egg. This holds true alike for the female-producing egg of the clutch, and for the late eggs, which under these conditions are predominantly female-producing, as compared with the group of earlier eggs which under the conditions of the generic cross are relatively male-producing.[6] Not only does the size of the egg increase with its later position in the series, i.e., with lateness of season, as shown by a mere comparison of the yolk weights of such a series of eggs, but the percentage of energy-yielding or stored materials increases as much, or probably more, than is indicated by the size, or net weight of the yolk. The per centage of water, we shall later see, is greater in the male-producing eggs.

For our present purpose the importance of the results of these and other analyses is that they conclusively show: (1) that the

[6] In this particular series, 8 of the first 9 eggs incubated produced males; the egg of this group that hatched a female was "a very large egg." The last three hatches were females.

male-producing egg of the spring is an egg that *stores* less material than does the female-producing egg of the autumn. (2)

TABLE 8

STORED ENERGY OF EGGS (1914) OF *Streptopelia risoria* (♀ 558) AS DETERMINED BY THE BOMB CALORIMETER

NO.	DATE	WT. OF YOLK	ENERGY	PER CENT DIFF.
665	A1 6- 6	[a]1.010	[a]3,358	
666	A2 6- 8	0.970	3,175	[b]− 5.8
674	B1 6-19	0.855	2,807	
675	B2 6-21	1.000	3,245	+15.6
699	C1 7-14	1.145	3,815 ?	
700	C2 7-16	1.463	5,008	+31.3 ?
728	D 8-30	1.395	4,812	
...	E 9- 9 or	10 soft shell, bro	ken.	
...	F1 10-17	soft shell, bro	ken	
...	F2 10-19	soft shell, bro	ken	
770	G1 11- 6	1.440	4,837 (?)	
771	G2 11- 8	1.720	5,797	+19.8 ?
774	H1 11-20	1.590 + sl. loss	4,906 +	
775	H2 11-22	1.780	6,015	+22.6 ?
776	I1 12- 1	1.640	5,614	
777	I2 12- 3	1.820	6,255	+11.4
781	J1 12-12	1.535	5,302	
782	J2 12-14	1.690	5,601	+ 5.6
791	K1 12-23	1.485	5,266 (?)	
792	K2 12-25	1.718	5,880	+11.7 ?

[a] This egg was not only the first laid during season, but first during life of this bird.

[b] The percentage differences are based upon a value of 100 per cent for the smaller egg of the pair.

That the male-producing egg of the clutch *stores* less material than does its female-producing mate. (3) That the eggs of old

females *store* more materials, and—as has been noted—yield a higher percentage of females, than do birds not old.[7] Therefore, it is evident that the egg of female-producing tendency is one whose *storage* metabolism is high, as compared with eggs of male-producing tendency. Moreover, the analyses show that during the season successive clutches present higher and higher storage, i.e., the earlier clutches store less—are more male-like; the later ones all store more—are more female-like—and as already noted the eggs of the low storage period give rise (in the generic cross) to males, and those of the high storage period produce females.

We here obtain a close view of that upon which sex difference rests. And the facts are now quite beyond question. Unmistakably, less storage and high storage pertain respectively to the male- and female-producing germs. Unmistakably, our procedures, connected with generic cross, season, and overwork, delivers males from the smaller storages in the earlier eggs. Unmistakably, the procedures raise the storage in all of the later eggs, and unfailingly we then find that these eggs yield only, or predominantly females. And if we eliminate the factor of wide (generic) cross and mate the female with one of her own or a very closely related species (Table 5), then we see that the production of males and females coincides from the first with two storage values—with two sizes of eggs (yolks) in the clutch—males from the smaller first, females from the larger second. Only after overwork and season have raised the storage value of the eggs is this situation seriously disturbed. And the disturbance—associated with an increase in the storage metabolism of all the eggs—delivers as before, an excess of female offspring (Tables 4, 5, 6).

The progressive *increase* in *storage* capacity of the eggs during the season—under overwork—is to be interpreted as a *decrease* in the *oxidizing* capacity of these same eggs. Living cells in general dispose of ingested food material by storing it or by burning it. If oxidized the products of the oxidation are removable and do not serve to increase the bulk of the cell. The

[7] See Tables 4, 5, 6.

low-storage capacity of the male-producing eggs as compared with the *high storage capacity* of female producing eggs is therefore an index of *higher oxidizing capacity* or as more usually stated, a *higher metabolism* of the male-producing eggs as compared with the female-producing eggs.

We may next examine the percentages of water in the eggs of spring and autumn, and in the two eggs of the clutch. These figures for one series of analyses are given along with other analytical results in Table 7. They show a higher water content for the eggs of the spring (male-producers). Indeed, each pair of eggs from the first of the season onward has a slightly higher moisture value than the pair that follows it. The analyses further show a higher percentage of water in the first egg of the clutch, i.e., in the male-producer, than in the second or female-producer in all cases.

If the results of my nearly 900 analyses all ran as smoothly as do the 8 of this series there would be no doubt of a perfect correlation of high moisture values with small eggs, i.e., with male-producing eggs—both small eggs of season, and small eggs of individual clutches. The results throughout, however, are not so uniform and smooth as here; there are some series which seem seriously to depart from the order noted above. These cannot be adequately discussed here. We can, however, record our own belief that the situation represented in the table is, in the main, indicated by the moisture determinations obtained in the analyses of eggs produced by pure species. Two additional methods of determining the amount of water in the yolks, give a satisfactory confirmation of the conclusion that the male-producing ovum contains a higher percentage of water than does the female-producing ovum.

It may be remarked at once that the two facts—a higher metabolism, and a higher water value in the same egg (the male-producing one)—are not to be regarded as a mere coincidence. They are related facts, essentially correlated in that the more hydrated state of these colloids, which contain only 54 to 59 per cent water, is certainly a more favorable state for a higher rate of (oxidizing) metabolism than is the less hydrated

state which better corresponds to a condition favorable to increased *storage*.[8]

The results of these analyses (as well as the calorimetric determinations to be mentioned later) have an important relation to the question of a modified or differential maturation, by which the changed ratios might be explained. Bearing on this point we may here make the following observations: It has been seen that the sex actually realized corresponds in fact to levels or grades of metabolism; and we now note that the (storage) metabolism which was measured *was complete before the beginning of maturation*, so that if such a differential maturation should occur it must be looked upon not as a *cause* but rather as a *result* of the establishment of that *grade of metabolism* which does here, and under all of the several known conditions, in the clearest way accompany and correlate with each particular sex.

But, any assumption of a differential maturation, even as a result of or response to these impressed levels of metabolism, brings with it more difficulites than it clears up. Among these it brings the paradox of a rigid selection *in favor of* the male-producing chromosome-complex in the maturations of the spring, and an equally rigid selection *against* this same complex in the autumn. Again, it is easily shown by simple breeding tests that such differential maturation does not occur in the spring at least when the female is mated to her own or a closely related species; so that a further assumption would have to be made to the effect that it is the *prospective* fertilization by a sperm from a wider cross that determines the course of maturation! Furthermore, our data on the sex-behavior of series of females from such a wide (generic) cross show that if the male-producing complex was indeed eliminated from the eggs that gave rise to one-half of these females (produced under overwork) these same chromosomes cannot be the real or sole cause of

[8] For example, Overton found that withdrawal of water from the cells of Spirogyra was followed by an increased *storage* or accumulation of starch, etc. Embryonic tissues generally have high water content and show most rapid division, differentiation and growth (*not* storage), etc.

masculinity, for as we shall see later a part of these females are strongly masculine, and indeed they show various grades of masculinity. The evidence against a differential maturation as a basis for an interpretation of the controlled sex ratios of pigeons is so strong as to cause its rejection, even if the essential constructive facts on the nature and basis of sex had not yet been learned.

The storage metabolism of many male- and female-producing ova, both in reference to egg of clutch and to position in the season, has been determined by means of the bomb calorimeter. The method is very accurate and the results are entirely convincing. The stored energy, or heat of combustion, of nearly 400 egg-yolks has been determined. One such series of determinations, (made in 1914) in which all available eggs of a particular female were burned is shown on Table 8. It will there be seen that the first clutch or pair of the season bore a higher caloric value than the second pair, but is otherwise the smallest of the year. Beginning with the second clutch laid in June the succeeding clutches to December 1 bear higher and higher heat values. In all clutches too, except the very first,[9] the second eggs show a higher storage of heat units than do the first of the clutch. Here we find the conclusions reached from studies on the wieghts of yolks, and on yolk analyses, fully confirmed by a method in which the error involved in the determination is wholly negligible. The most accurate method for the study of the storage metabolism of male and female producing ova give too the results most consistent with the breeding data. In other words, we could say, if we wished to make merry with our colleagues, the cytologists, that we here get closest to the facts of sex when we *burn* our chromosomes!

The energy values obtained from the burned yolks, permit an indirect comparison of the water values of the male- and female-producing eggs of the clutch. Such a comparison indicates, as in the chemical analyses, a higher percentage of

[9] Professor Whitman has observed that the very first egg in life or of the season is more likely to throw a *female* than is the first of the clutch of the immediately succeeding clutches.

water in the male-producing ovum. In addition to these two methods of studying the water values of the two kinds of eggs the value has been obtained direct, by desiccation, on a considerable number of samples. The three methods confirm each other. A little later we shall make a further application of the observed facts of higher water values, and of a higher metabolism in the male-producing ova.

Let us now very briefly consider the other kinds of observations that have been made on the series of eggs, from spring to autumn, produced under crowded reproduction by generic crosses, as these are schematically represented in Chart 1. Curves 2 and 3 on that chart represent facts which were first observed by Professor Whitman on these series of eggs. The curve entitled "developmental energy" (No. 2) represents the observed fact that more of the eggs of spring show the capacity to develop than do those of autumn; and by the use of a continuous (not broken) line or curve is indicated the further fact that the first eggs of the clutch bear throughout the season a similar relation (of higher fertility) to the second eggs of the clutch. The curve marked 3 and designated "length of life" tells again of an advantage possessed by the earlier hatched birds, and of a more limited life-term affixed to the hatches from the later "overworked" eggs. It is probable, moreover, that within the group of clutches giving rise to females only, a longer life-term falls to those birds arising from the first egg of the clutch than from those arising from the second of the clutch. Here, then, as in the preceding curve (2), the smaller eggs of both clutch and season are the eggs which give in their development the tests of "strength and vigor," while the larger eggs of clutch and season more often display "weakness."

The data which justify curves 4 and 5 as represented on the chart have already been considered. Of the observations upon which curve 6 is based we shall here say only that in general the weight of the parent bird is greatest at the season when the weights of the yolks being produced are smallest, and that when the largest yolks of autumn are being produced the weight of the parent bird is the smallest of the year. Tables 4 and 5

were prepared originally to make clear certain observations on size of off-spring in relation to their origin from eggs produced under overwork, after continued overwork, and in relation to the order of the eggs in the clutch. The tables themselves tell much of their story and we here forego a further consideration of them (see RIDDLE, '16, p. 406).

The seventh curve of Chart 1 refers to a long and rather large series of tests of the sex-behavior of series of birds such as those whose origin is indicated in Table 3 (series of 1908). We have here an opportunity to study and compare sex phenomena of particular birds whose sex we have reason to believe had been reversed from its initial sex-tendency; that is to say, where successive pairs of females have originated from successive pairs of eggs in the autumn, under overwork, we have the reasons already given for believing that some or most of such females arising from first eggs of the clutch have had their metabolism depressed to a point sufficient to make them females; but the second eggs of the *same* clutches should by the same means have been carried to a still more "feminine" level; and though both are females, it seemed possible to differentiate the one sort from the other, and this has been successfully done in a series of tests which now extend through a period of nearly five years. Each female has been given about nine tests, each of six months duration, with (for the most part) another *female*.

In this study, then, female is mated with female and male with male. Such pairs, from a very few selected pairs of parents, are kept mated for a period of six months. Most of the birds used, for lack of success with the incessantly fighting males, have been females, and most of the nine or ten successive tests with each bird have been made with her own sisters. The members of the pair are kept apart except when under observation; when put together, as is done twice daily, the records are taken of those females of the pair which behave as males in copulating with their mates. Three facts are definitely established by the data obtained: (1) The females of the *orientalis* × *alba* cross (they are dark in color) are more male-like in their sex behavior than the females of the reciprocal cross (these

are white in color). (2) Females hatched from eggs laid earlier in the season are more masculine in their sex behavior than are their own full sisters hatched later in the season. *And, several grades of females can be thus seriated according to season of hatching.* (3) The female hatched from the first egg of the clutch is more masculine than her sister hatched from the second of the clutch in a great majority of the cases. And in nearly all these latter matings the more masculine bird is so predominantly masculine that she takes the part of the male a full 100 per cent of the time in copulating with her very feminine clutch-mate sister. (See RIDDLE, '14*a*).

I may remark in passing that the effect of testicular and ovarian extracts (suspensions) have been studied in connection with the work on sex-behavior. The results have clearly shown that the sex behavior of a pair of females is modified by the intra-peritoneal injection of testis (pigeon) extract into the one and ovarian (pigeon) extract into the other. In one case, for example, the more "feminine" female of a pair was given testis extract and her more "masculine" mate received ovarian extract. After the injections the bird formerly more feminine, 16 copulations as a male to 23 by her consort, became very much the more masculine, 27 copulations as a male to only 2 by her consort.

To one other kind of fact concerning the effects of reproductive over-work in changing the developmental and sex phenomena of the germs of the later part of the season, we ask a moment's consideration.

It has been found that some females dead at relatively advanced ages show persistent right ovaries. The right ovary in pigeons normally begins degeneration at or before hatching and is usually wholly absent from the week-old squab. In our study it soon became evident that the persistent right ovaries were found almost exclusively in birds hatched from eggs of overworked series. Further study has shown in addition that they arise almost wholly from the eggs of autumn, and predominantly then from the second eggs of the clutch—that is from eggs otherwise known to have greatest or strongest

female-producing tendency. These ovaries have sometimes weighed half or more than half as much as the adult left ovary with which they were associated, and have been found in such birds dead at all periods from a few days to twenty-four months. We here attempt no adequate description of this situation, but one can not have observed the frequency of the persistence of this ovary in the birds hatched from the eggs otherwise known to be the most feminine from these overworked series, without conviction that the same pressure which carries the eggs of spring from male-producing to female-producing levels, also carries the earlier female-producing level to another yet more feminine.

The several kinds of facts just reviewed in connection with Chart 1 afford clear evidence that sex and characteristics other than sex such as fertility and developmental energy not only bear initial relations to the order of the egg in the clutch, but that sex and these other characteristics are *progressively modified* under stress of *reproductive overwork*, until at the extreme end of the season certain aspects of femininity are abnormally or unusually accentuated. In the light of these facts sex reveals itself as a quantitative modifiable character. And an association of modifiable metabolic levels with the flux and change of sex, or of sex ratios, has been found and described in precisely this same connection.

Let us now take these facts with us in a rapid survey of some experimentally induced and puzzling sex-ratios, and also into a brief consideration of some important facts of sex that have been learned from embryonic and post-natal stages of organisms.

The evidence that higher water values and higher metabolism are associated with male-producing eggs, lower water values with female-producing eggs, is of first importance in connection with our own generalization as to the germinal basis of sex-difference; and is further of much interest as being the means of demonstrating that in the—as I believe—several valid cases of sex-control now known, one thing in common has really been effected; this, though the work has been carried out on a considerable variety of animals and though the procedures have

themselves been most various. The thing that seems to have been effected in all cases has been the raising or lowering of the general metabolism of the treated germs. In probably none of the cases in which these experimentally induced abnormal sex-ratios were obtained—in other animals than the pigeon—has the observer been able definitely to eliminate all the possibilities of the continued determination of sex by the sex-chromosome; but several observers have been able to eliminate one or more of these possibilities for their material. And all of those experi-

TABLE 9

Time of Fertilization and the Sex Ratio in Cattle

AUTHOR	TIME ♂: ♀	AUTHOR	TIME ♂: ♀
Thury and Cornaz.........	Early 0: 7 Late 22: 0	Russell..........	Early 31: 51 Late 42: 34
Düsing[a]..........	Early 8: 10 Late 4: 1	Pearl and Parshley......	Early 123: 125 Middle 67: 58 Late 65: 42
Düsing[a]..........	Early 3: 10 Late 1: 1		

Total[b]	Early	134: 178, ratio = 75.3 ♂: 100 ♀
	Middle	67: 58, ratio = 115.5 ♂: 100 ♀
	Late	77: 44, ratio = 175.0 ♂: 100 ♀

[a] Work cited by Düsing.

[b] Omitting the data submitted by Cornaz in the first announcement of the theory.

ments which strongly suggest a real sex reversal or control can now be shown to be in alignment with one or more of the basic facts of sex control now known in the doves and pigeons. When the conditions of these experiments have been such as to lead us to expect an *increase of the metabolism*, males have been produced in excess, and when the conditions imposed have been obviously capable of *depressing the metabolism* of the treated germs, these have yielded an excess of females. These facts, therefore, afford much reason for the opinion that sex has been controlled or reversed in a number of very different animals.

The observed relation of the time of fertilization to modified sex-ratios in cattle is summarized in Table 9. Thury reported in 1862 that from fertilizations made in the early period of heat in cattle an excess of females were produced; and that later (delayed) fertilizations give rise to an excess (*all* according to Thury) of males. Similar experiments have been several times repeated and these repetitions have all shown an excess of one or the other sex in accordance with such early or late fertilization.[10] The facts as reported by the several observers, and the totals, are given in the table. We postpone for a moment a discussion of the situation presented by these data except to

TABLE 10

TIME OF FERTILIZATION AND SEX RATIO IN SHEEP

Bell[a]	Matings in October, 1899	♂ 10: ♀ 26	= 72.0 per cent ♀
	Matings time unknown, 1899	♂ 179: ♀ 166	= 48.0 per cent ♀
	Matings after November 15, 1899	♂ 23: ♀ 3	= 11.5 per cent ♀

[a] Records of a neighboring flock supplied to Dr. Bell by Mr. Macrae.

draw attention to the probability that in late (delayed) fertilization the ovum *takes up* water before fertilization and gives an excess of males.

Connected with these facts obtained from cattle are some partially similar data for sheep. From records obtained by Dr. Alexander Graham Bell ('14), made primarily with the object of learning whether certain conditions have an influence on "twinning" in sheep, the materials for Table 10 have been taken. Here, again, as in cattle there is probably some evidence for an increased male production from delayed fertilizations.

Experiments on the frog and the toad have afforded evidence for the control of sex. Richard Hertwig ('06, '12), and later Kuschekewitch ('10), allowed frog's eggs before fertilization to "overripen," a process during which *the eggs take up water*—

[10] The use of the terms *early* and *late* fertilizations assume that some ovulation occurs either immediately before, or shortly after, the beginning of heat.

and obtained (the latter author) in some cases a total of 100 per cent males (Table 11). Dr. King ('12) did the converse of this experiment with toad's eggs—withdrawing water from them before fertilization—and obtained nearly or quite 80 per cent of females in cases where the mortality was less than 7 per cent.

The evidence afforded by these experiments on the frog and the toad is thought by many to be inconclusive as evidence for real sex control. Though selective fertilization has been eliminated as a possibility by Kuschekewitch, we do not know which is the heterogametic sex in amphibia and there also remains the

TABLE 11

EXPERIMENTALLY MODIFIED SEX RATIOS IN FROGS AND TOADS

AUTHOR		TREATMENT	RESULT ♂	RESULT ♀	♂
					per cent
Hertwig, R.	frog	Delayed fertil. (+ H_2O)	271	0	100.00
	frog	Delayed fertil. (+ H_2O)	...	...	88.88
Kuschekewitch	frog	Delayed fertil. (+ H_2O)	299	0	100.00
King, H. D.	toad	No delay + H_2O	62	41	60.20
	toad	No delay − H_2O	106	275	27.66
	toad	No delay − H_2O	85	289	22.73

possibility of parthenogenetic development to account for the excessive male-production in the experiments with the frog. But this appeal makes it impossible to explain the great excess of *females* obtained by Dr. King on the eggs of the toad, where a selective mortality is definitely excluded, and leaves such doubters to lean upon the rather discredited staff of selective fertilization—a proposition wholly disproved for the related frog and for the pigeon. It may be noted, however, that on the basis of our present knowledge of the "sex-differentials" (to be considered later) in the pigeon's eggs both of these experiments

might have been predicted to result as these three investigators have reported.

The modified sex ratios obtained from the four types of animals just mentioned were all obtained through action upon the eggs, or the egg-stage of the organisms. Some important experimental work, and other very significant physiological and chemical study, has been done on sex in the embryonic and adult

CHART 2

Bonellia; Free-martin; Inachus; Frog; Pigeon; Duck; Fowl; Pheasant; Sheep; Human; Stag.

Egg
- Cow
  - ♂ high per cent H_2O (?)
  - ♀ low per cent (H_2O (?)
- Pigeon
  - ♂
    - low fat and P.
    - HIGH METABOLISM
    - high per cent H_2O
  - ——————→ *Adult*
  - ♀
    - high fat and P.
    - LOW METABOLISM
    - low per cent H_2O
- Frog / Toad
  - ♂ high per cent H_2O
  - ♀ low per cent H_2O

Adult
- Human
  - ♂
    - (blood) low per cent fat
    - HIGH METABOLISM
  - ♀
    - (blood) high per cent fat
    - LOW METABOLISM
- Fowl
  - ♂ (blood) low fat and P.
  - ♀ (blood) high fat and P.
- Crab
  - ♂ (blood) low per cent fat
  - ♀ (blood) high per cent fat

Hydatina
- ♂'s from change of food and increased oxygen supply.
- ♀'s from unchanged food and lesser oxygen supply.

Daphnids — sex-intermediates—sexual or asexual reproduction influenced by conditions.

Moths — sex-intermediates—quantitative germinal basis.

stages of the organism. Something can here be gained by grouping and treating these several results in a single diagram.

Now that the basic problem of sex has been shown to be essentially a question of metabolism, a department of physiology and biochemistry, we shall be able to note in connection with Chart 2 (where the principal known facts concerning the relation of metabolism to sex are diagrammatically arranged) that a num-

ber of data bearing on adult sexual differance of the sort we most require are already at hand.

Turning now to the diagram we note that *egg* and *adult* stages are first distinguished. In the *egg* of the pigeon we have identified maleness and femaleness by three differentials. Femaleness in the egg-stage being accompanied by *low metabolism*, lower percentage of water, and higher total fat and phosphorus, or of phosphatides. Maleness is here accompanied by high metabolism, higher percentage of water, and lower total fat and phosphatides. Now there are valid reasons for treating these three differentials not as separate and disconnected facts, but rather as aspects or corollaries of the same fact. For example, a

TABLE 12

SEXUAL DIFFERENCES OF FAT AND PHOSPHORUS IN THE BLOOD OF ADULT FOWLS AND OF MAN

SEX	AVERAGE TOTAL FAT	AVERAGE TOTAL PHOSPHORUS	RELATIVE AMOUNTS OF PHOSPHORUS
Males (roosters)	15.45	6.43	100
Non-laying females	17.87	7.42	115
Laying females	27.80	13.15	205
Males (man)	141.4		
Females (women)	226.0		

high metabolism in a cell is consonant with less storage of fat and phosphatides, and with a more *highly hydrated state* of the cell-colloids. It follows that where data for either of these three differentials are at hand, for either the germ or adult of any animal, we have in such data evidence of the kind we are looking for, i.e., evidence for the association of a given type of metabolism with the germ or adult of a given sex.

For what forms then are such data available? And, what is now known of the *persistence* of this definite type of differentiation of the two kinds of sex germs into *adult stages* of the two sexes? Recently, in my laboratory in coöperation with Mr. Lawrence ('16), it has been shown that one of these differentials

—or one aspect of *the* differential which our own work has demonstrated in the egg—is clearly continued in the *blood* of the adult male and female. Fowls were substituted for doves in this case in order to increase the size of the samples and thus increase the accuracy of the analytical results. The blood of the male contains less fat and less phosphorus—just as the male-producing egg contains less of these same elements. The data further show that the sexually active (or actively functional) females depart most widely from the male, while sexually inactive females occupy an intermediate position in respect of the amounts of these constituents found in the blood (see Table 12).

The results afford fairly clear evidence that in birds *the metabolic differences of male and female germs persist in the male and female adults.*

In mammals too these aspects of sexual differences of the adults have been fully demonstrated. Almost simultaneously with the above determinations on birds, data were published by Goettler and Baker ('16) which (as we have pointed out, '16) show that the blood of the human male contains less fat, that of the female more. Further, the *basal metabolism* of the human male and female has recently been accurately determined by Benedict and Emnes ('15); they find that the metabolism of man is 5 to 6 per cent higher than that of woman.

Have we any measure of either of our differentials in any mammalian *egg?* I think that the experiments on sex-determination in cattle, together with an observation by van der Stricht, afford some evidence that the water content of the male-producing egg is high, and that of the female-producing egg is low. No one definitely knows whether the ovum of the cow absorbs water in the Fallopian tubes in this interval between ovulation and fertilization, but we do know that every amphibian, reptilian, and avian egg that has been investigated does absorb very appreciable amounts of water while being passed from the ovary to the exterior. And van der Stricht has described phenomena of growth or swelling of the yolk-granules of one mammal—the bat—which, I am sure from my own studies on yolk, indicate the taking up of water by the egg of this mam-

mal. It is highly probable, therefore, that precisely that *time relation* which leads to an excess of males in cattle is preceded or accompanied by an increased hydration of the ovum. In mammals therefore there is some evidence that a shift of the metabolic level—as indicated by one partly known differential —is associated with the observed changes in the sex-ratio of the germs which are thus modified. Further, in the adult of one mammal—man—two of the three sex-differentials have been definitely demonstrated. These results for both the egg and adult stages of the mammal are at every point in complete agreement with our data for both the egg and adult stages of the bird.

How now do the controlled sex ratios obtained in the frogs and toads appear in the light of the sex differentials of our diagram? Clearly the data given in Table 11 arrange themselves in perfect agreement with the metabolic differentials which obtain in birds and mammals. The data of that table eliminate "delayed fertilization" *as such* as being a factor and show that the altered sex ratios correspond with increase or decrease of water as the *sole known* differential.

We next give a moment's consideration to an adult stage in which a change in metabolism was observed in connection with sexual changes. In the spider-crabs Geoffrey Smith ('11) showed that both the blood and the liver of the adult male crabs contain less fat than do the blood and liver of the females. Here once more the facts concerning one of the sex-differentials is known and is in complete accord with all the preceding cases. In these spider-crabs, known to be sometimes castrated by parasites, Smith and Robson were able to show, moreover, that the *parasitized male crabs, which under these conditions gradually assume several female morphological characteristics, are also found to have assumed the type of fat metabolism which characterizes the normal female crab.* How much these facts contribute to, and how completely they adjust themselves to, our own general theory, will be realized only after a moment's reflection. Recently Kornhauser ('16) has found some of these conditions also in *Thelia.*

A glance at the diagram indicates three other groups of animals which experimental work has thrown into the general question of the control of sex. The information at hand for these forms does not so expressly concern the *egg* as does that from the preceding cases, but all of these latter groups are concerned with early stages—some of them with the generation preceding the egg whose sex seems influenced by conditions. The results of studies of the first of these groups—Hydatina—are of such a kind as to show that they are in general accord with the metabolic differentials of all of the previously mentioned cases of sex-control. One cán scarcely doubt that *change* of food and *increased* oxygen supply are consonant with increased metabolism, just as the studies of Whitney ('14 and later) particularly, and later of Shull ('16), have shown that these changes lead to the production of male-producing daughters.

The second of these groups—the Daphnids—have been studied by three independent investigators who agree upon two points that are of importance in the question of the control of sex, and to the general theory of sex as stated here, though the results throw little light on precisely what is causally involved. Issakowitch ('05), Woltereck ('11), and Banta ('15) all find numerous *sex-intergrades* in a material in which all agree that the type of reproduction—sexual or asexual—is influenced by environmental conditions. All further agree that "unfavorable conditions" (or is it a *change* from favorable conditions?) tends toward *sexual* reproduction, while "favorable conditions" favor asexual reproduction.

In the third of these groups—the moths—the studies of Goldschmidt ('12, '14), Goldschmidt and Poppelbaum ('14), Harrison and Doncaster ('14), and the work of Machida, have demstrated again sex-intermediates of various grades. Moreover, it has been shown that from among the various geographical races of moths certain matings can be arranged which produce rather definite types of male- or female-intermediates—or sex-intergrades as Goldschmidt elects to call them. And further, from pairs involving still other species still other levels or grades of sex-intermediates may be freely obtained. A more or less fac-

torial basis of the phenomena has hitherto been used in the discussion of these results; but recently Goldschmidt ('16) has stated that "very important new facts will be published later which will probably enable us to replace the symbolistic Mendelian language, used here, by more definite physico-chemical conceptions." Such newer descriptions—we would say—is wholly in line with the requirements of present data on sex. In Whitman's and our own material it has been clear from the first that the results far overstep the possibility of treating them in Mendelian terms, for it has been apparent from the beginning that we have had to do not with three or four points merely, but with a *flowing graduated line.* In the work with the moths, however, sex is clearly described in *quantitative* terms, and it seems fairly certain that when the functional basis of sex shall have been identified it will be found that sex accords with metabolic grades there, as it does elsewhere.

It is clear then that all of the animal-forms for which there is reasonable evidence of sex-control show important correspondences with the situation fully elucidated in the pigeons. And that where the sex-differentials known to exist in the pigeon's ova have been traced in adults of the two sexes, the parallel rigorously holds there also. A general classification of male and female adult animals on the basis of a higher metabolism for the one and a lower for the other, was indeed made by Geddes and Thomson ('90) many years ago. It now seems beyond question that this conclusion of these authors is a correct and important one.

It remains to point out that another very old and much worked line of investigation supplies further confirmatory evidence for our present point of view. Studies on the effects of castration, gonad-transplantation, and gonad-extract injection, constitute a large body of observations which deal with sexual phenomena associated with the *internal secretions* of the sex-glands. These internal secretions, let it be remembered, are themselves *metabolites,* which have the capacity to *influence the metabolism* of some, many, or of all the tissues with which they

come in contact or which they may reach indirectly.[11] A partial list of the animal forms that have been most studied in this respect is written serially on the top of our diagram—in a position intermediate to egg and adult. The number of these animal forms might be much increased, and the names of the investigators of this aspect of the modification of sex are quite too numerous[12] to be mentioned here. But the present point of interest is that these results, as a whole, demonstrate that *the extent of sexual modification in the experimental animal is, in general, in proportion to the immaturity of the treated animal.* That is to say, the earlier the internal secretion of the gonad is supplied or withdrawn—the earlier the metabolic change is effected—the more profound is the sexual modification of the individual. All this is of course clearly in conformity with the Law of Genetic Restriction—a principle of embryology that is true alike for all of the known characteristics of the organism.

Of the several animals of the list we may here particularize concerning only two or three. The stag is a form that has long been known to show thus a considerable and beautiful series of greater modification of antlers and other so-called secondary sexual characters, in correspondence with castration at earlier and earlier periods in the life of the animal. The free-martin —another Ungulate—is now known to exemplify a much earlier point at which the foreign internal secretion begins to act;

[11] That changes following the removal of gonads, etc., have for many years been recognized as connected with a changed *metabolism* may be illustrated from the following quotation from Marshall ('10). "The effects of castration indicate that an alteration in the metabolism, even in comparatively late life, may initiate changes in the direction of the opposite sex" (p. 658).

[12] The following partial references are suggested by the particular animals listed in the diagram: *Stag*, DARWIN (1868); CATON (1881); FOWLER (1894); RÖRIG (1900). *Human*, HEGAR (1893); SELHEIM (1898); HIKMET and RENAULT (1906); C. WALLACE (1907); TANDLER and GROSS (1909). *Sheep*, SHATTOCK and SELIGMAN (1904); SELIGMAN (1906); MARSHALL and HAMMOND (1914). *Guinea-pig*, BOUIN and ANCEL (1903–9); STEINACH (1910–13). *Pheasant*, GURNEY (1888). *Fowl* and *Duck*, DARWIN (1868); GURNEY (1888); FOGES (1903); SHATTOCK and SELIGMAN (1906–7); GOODALE (1910–16). *Pigeon*, RIDDLE (1914 *a*). *Frog*, NUSSBAUM (1907); PFLÜGER (1907); STEINACH (1910); G. SMITH (1912). *Inachus* and *Carcinus*, POTTS (1909); G. SMITH (1910–12). *Free-martin*, LILLIE (1916). *Bonellia*, BALTZER (1914).

and here, true to the rule that has been established elsewhere in all this general line of work, the resulting modification is correspondingly strong and striking. When, by whatever means, we effect a change in the metabolism (which is the essential thing) at a still earlier stage—in the egg-stage in our own and in some other experimental reversals of sex—then we obtain individuals whose sexual nature is quite thoroughly reversed;[13] in many cases completely so, and in still other cases with varying degrees of completeness.

Baltzer's ('14) beautiful experiments with the worm Bonellia best illustrate this fact and show the several stages of modification not only in one and the same animal form but in the individuals hatching from a single brood. Baltzer finds that when the larvae of this animal are hatched they are capable of becoming either males or females. If they happen to become attached to the proboscis of an adult female they become males; if they do not succeed in so attaching themselves they soon settle from the water into the sand or mud of the sea-bottom and there undergo, quite slowly, further development into *females* (almost exclusively). The plastic, reversible, quantitative nature of sex in this form was shown by this investigator in the following way: Some of the free-swimming "indifferent" larvae were artificially helped to a connection with the proboscis of an adult female. Some of these were permitted to maintain this attachment for a very short period; others were removed at progressively longer periods, with the very significant result that practically all stages of hermaphroditism were produced. Those first removed becoming almost perfect females, others with longer and longer periods of attachment, becoming more and more perfect males.

Now the conditions under which the two sexes are here developed afford, in our own opinion, good reasons for believing that the larva is stimulated—through its contact with the living

[13] The observations of Steche ('12) on the relation of *precipitin* reactions to sex, as seen in the blood of insects are of much interest. This author thus finds that male and female of the same species present differences as great as do the males of two related species, or as do the females of related species.

tissue—to a *higher* metabolism; supporting this point of view is the observed fact that "differentiation" is much hastened in this male individual as compared with the otherwise wholly similar larva that is destined to become a female.

What it has been our privilege and opportunity to present is in itself but an outline or summary of result obtained in the modification and control of sex, and of the conclusions that seem to follow from these results. In a closing statement, therefore, we wish only to direct attention to some consequences of the new knowledge of sex. As a foreword to this statement, however, we would note that not only do the widely different kinds of fact to which we have made reference directly support the view of the basis of sex here presented, but that nothing known of the sex-chromosomes is necessarily opposed to this view although an abundance of the data here presented sharply oppose the conception that the sex-chromosomes are a *cause* of sex, or that they are even a necessary associated phenomenon. We may conceive that sexually differentiated organisms, from the first, have had the problem of producing germs pitched at two different metabolic levels; and if two sharply opposed sexes are to result from these two kinds of germs then the two metabolic levels must be measurably distinct. This task of producing and maintaining two kinds of cells pitched at two different levels ultimately falls upon *cells*, and these have, sometimes at least, produced two different chromosome complexes in connection with or in accomodation to the establishment of these two metabolic levels. But, as we have seen, the requisite metabolic level of the germ may be established in the absence of the appropriate chromosome complex, and the sex of the offspring made to correspond with the acquired grade or level of metabolism.

With these facts concerning the functional basis of sex in mind, and reverting to our first quotation from Doncaster, how little wonder that sex (despite its seeming "lack of function" is "nearly universally distributed," almost coequal with "the fundamental attributes of living matter, irritability, assimilation and growth?" Since *some* grade of metabolism is of necessity universally present in living matter the basis for two

sexes is of equally wide distribution in that sexual differentiation results from metabolic differentiation, through the establishment of two relatively distinct and relatively stable levels of metabolism. In the same way is accounted for the hitherto puzzling fact that the two sexes must have originated many times, scores, hundreds, or thousands of times, within species previously unisexual, during the long period involved in the evolutional history of organisms.

Most important of all, perhaps, is the demonstration that one *hereditary* character is modifiable, is of a fluid, quantitative, reversible nature. Seemingly this can only mean that other hereditary characters are also modifiable. The methods and results of most studies in modern genetics have asked us to accept a quite different view, namely that no such thing as control of heredity may be hoped for, but that we can only look to a sorting and elimination of germs, or of so-called hereditary factors—and to fortuitous origins or recombinations of the latter—to give us better or more desirable organisms. Surely there is a lot of fatalistic philosophy in that conception. All other aspects of function in biology recognize—and some have already attained—the *control* of life-processes as their aim and goal. Only in this field of heredity—involving the overwhelmingly important processes of continuance and of becoming—has this aim been accepted by a great and growing body of workers as impossible. If sex has been in fact controlled, if it has a modifiable metabolic basis—as now seems assured—then the life processes involved in heredity like other life-processes, invite the investigator to his full and complete task; territory hitherto labelled "impossible" is open to investigation.

BIBLIOGRAPHY

BALTZER, F. Arch. f. Zellforsch., vol. 2, 1909.

BALTZER, F. Mitteil. Zoöl. Stat. Neapel., vol. 22, 1914.

BANTA, A. M. Year Book, Carnegie Inst. Wash., 1915. (Also Proc. Nat. Acad. Sci., vol. 2, 1916.)

BELL, A. G. Quoted from Popenoe. Jour. Hered., vol. 5, p. 47, 1914.

BENEDICT, F. G., and EMMES, L. E. Jour. Biol. Chem., vol. 20, 1915. These authors give full references to the earlier literature.

DONCASTER, L. The Determination of Sex. Cambridge, 1914.
DÜSING, C. Jenaische Zeitschr., Bd. 17, p. 593, 1884.
GEDDES, P., and THOMPSON, J. A. The Evolution of Sex. Humboldt Publishing Co., New York, 1890.
GUYER, M. J. Biol. Bull., vol. 16, p. 193, 1909.
GOETTLER and BAKER. Jour. Biol. Chem., vol. 25, 1916.
GOLDSCHMIDT, R. Zeitschr. f. indukt. Abstamm., vol. 7, p. 1, 1912.
GOLDSCHMIDT, R., and POPPELBAUM, H. Zeitschr. f. indukt. Abstamm., vol. 11, p. 1, 1914.
GOLDSCHMIDT, R. Amer. Nat., vol. 50, p. 705, 1916.
HARRISON, J. W. H., and DONCASTER, L. Jour. Genetics, vol. 3, p. 16, 1914.
HERTWIG, R. Verhand. deutsch. Zoöl. Gesellsch., 1906; see also Biol. Centralb., vol. 32, p. 1, 1912.
ISSAKOWITSCH, A. Biol. Centralb., vol. 25, 1905.
KING, H. D. Jour. Exp. Zoöl., vol. 12, p. 19, 1912.
KORNHAUSER, S. I. Abstract. Science, N. S., vol. 43, Feb. 1916.
KUSCHEKEWITCH, A. Festschr. f. R. Hertwig, 1910.
LAWRENCE, J. V., and RIDDLE, O. Amer. Jour. Physiol., vol. 41, 1916.
MARSHALL, F. H. A. The Physiology of Reproduction. London, 1910.
MORGAN, T. H. Science, N. S., vol. 36, p. 718, 1912.
PEARL, R., and PARSHLEY, H. M. Biol. Bull., vol. 24, p. 205, 1913.
PHILLIPS, J. C. Jour. Exper. Zoöl., vol. 16, p. 131, 1914.
RIDDLE, OSCAR. Paper before Amer. Soc. Zoöl., Dec. 1911. Abstract, Science, N. S., vol. 35, p. 462, March, 1912.
RIDDLE, OSCAR. Year Book, Carnegie Inst. Wash., vol. 12, p. 321, 1913.
RIDDLE, OSCAR. Abstract (paper before Amer. Soc. Zoöl., Dec. 1913.) Science, N. S., vol. 39, p. 440, 1914 *a*.
RIDDLE, OSCAR. Bull. Amer. Acad. Med., vol. 15, p. 265, 1914 *b*.
RIDDLE, OSCAR. Year Book, Carnegie Inst. Wash., vol. 13, p. 382, 1914 *c*.
RIDDLE, OSCAR. Amer. Nat., vol. 50, p. 385, 1916.
RIDDLE, OSCAR. Science, N. S., vol. —, 1917 (in press).
RUSSELL, F. L. Ann. Rept. Maine Agr. Expt. Sta., p. 208, 1891.
SHULL, A. F. Abstract, Science, N. S., vol. 53, 1916.
SMITH, G. Quart. Jour. Micr. Sci., vol. 57, 1911.
TENNENT, D. H. Jour. Morph., vol. 23, p. 17, 1912.
THURY, M. Ueber das Gesetz der Erzeugung der Geschlechter, 1862 (translated into German. Leipsic, 1893).
SUCHETET, ANDRE. Des hybrides a l'etat sauvage; oiseaux, vol. I, Lille, 1896.
STECHE, OTTO. Zeitschr. f. indukt. Abstamm., vol. 8, p. 284, 1912.
WHITMAN, C. O. Posthumous Works, Vol. II. The Carnegie Inst. Wash. (in press).
WHITNEY, D. D. Science, N. S., vol. 39, p. 832, 1914. (Also, Jour. Exp. Zoöl., vol. 17, 1914, and later papers).
WOLTERECK, R. Intern. Rev. d. gessammst. Hydrobiol., vol. 4, 1911–12.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Tungsten deposits of northwestern Inyo County, California.* ADOLPH KNOPF. U. S. Geological Survey Bulletin 640-L. Pp. 21. 1917.

Tungsten deposits were found in northwestern Inyo County, California, in 1913 but remained practically unknown until the spring of 1916, when they began to be energetically developed. By midsummer two mills, having a total daily capacity of 400 tons, had been completed and were in active operation.

The ore consists of scheelite associated mainly with garnet, epidote, and quartz. The country rock is prevailingly granitic, but in it are isolated masses of limestone which became mineralized shortly after the granitic rocks were intruded. The limestones were altered to masses of garnet carrying subordinate scheelite by the metallic vapors then given off, and these altered rocks are the tungsten deposits now under exploration. The ore bodies that are being mined are from 20 to 60 feet wide and from 150 to 260 feet long. They carry from 1.5 to 2 per cent of tungsten trioxide (WO_3). The area in which scheelite-bearing deposits have been found forms roughly a belt 20 miles long, but it is likely that the prospecting now going on will extend the dimensions of the field.

These deposits, like those discovered in recent years in Humboldt County, Nevada, belong to the contact-metamorphic class, a well-known source of copper and iron but not widely recognized as a possible source of tungsten. A. K.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 570th regular meeting of the Society was held in the Assembly Hall of the Cosmos Club, Saturday, April 21, 1917; called to order at 8 p.m. by President HAY; thirty-five persons in attendance.

On recommendation of the Council, S. S. VORHEES of the Bureau of Standards was elected to membership.

Two communications were presented:

A. H. HOWELL: *Notes on American flying squirrels.* Mr. Howell spoke first of the general zoologic position of flying squirrels, then of their external characters and habits, their mode of "flight," food requirements, etc. He gave a brief résumé of the generic names that have been applied to the American flying squirrels. The main part of Mr. Howell's paper dealt with his recent systematic study of the group, a consideration of the various species and subspecies, their interrelationships and geographic distribution. Maps showing the distribution of all the American forms were exhibited as well as skins of the more important members of the genus. W. P. TAYLOR, A. WETMORE, R. W. SHUFELDT, and W. P. HAY took part in the discussion, in which it was brought out that flying squirrels have apparently no natural enemies save certain owls, and that extraordinary numbers of individuals of flying squirrels, at least several dozens, may be found inhabiting a single tree.

O. P. HAY: *On the finding of supposed Pleistocene human remains at Vero, Florida.*

Having described the geography, topography, and geology of the region about Vero, the speaker presented his conclusions.[1]

1. The problems to be solved at Vero concern primarily the geologists and paleontologists; only secondarily the anthropologists. For, little that is certain is yet known about the beginning and the course of human history on this continent.

2. Because of the small number of bones belonging to each human skeleton found at Vero and their scattered condition, it is unreasonable to suppose that they were purposely buried where found.

3. These bones must have reached their recent positions before the deposition of the muck layer, Sellard's No. 3, unless human bones possess some unexplained means of underground dispersal.

[1] In order to understand the matters involved consult Journ. Geol., **25**: 1–62. 1917.

4. The Pleistocene fossils in No. 2 are there because the animals died there. They were not washed in from the region further back, principally because there were no fossils there to be washed in.

5. The Pleistocene fossils of No. 2 belong to the early Pleistocene, as shown by the character of the species and the high percentage (74) of the extinct forms.

6. The Pleistocene fossils in No. 3 represent animals which died there. They were not washed in from above. They were not washed up from No. 2, because of (*a*) frequent association of parts of the same skeleton, (*b*) the good state of preservation, (*c*) the early protection of No. 2 from erosion by the blanket of muck, No. 3.

7. So far as determined, the extinct species in No. 3 form about 44 per cent of the whole number—almost exactly the same as in the case of the Conard fissure in Arkansas. The fauna just referred to probably belongs to the Illinoian stage.

8. Possibly the geological conditions may permit the conclusion that some parts of No. 2 were reworked about the middle of the Pleistocene and that then the human bones were included.

9. There are independent evidences that man with a culture much like that of modern Indians existed in America during approximately the Sangamon stage. Some of these are:

a. The finding of a human pelvis below the loess at Natchez and associated with extinct animals.[2]

b. The discovery of flint arrow-heads at Muscatine, Iowa.[3]

c. The finding, at Muscatine, of flint chips at a depth of 10 feet in a gravel bed from which an elephant tooth had been taken.[4]

d. The discovery of a stone axe at Council Bluffs in loess at a depth of 35 feet.[5]

e. The finding of a stone axe near St. Louis in loess at a depth of 14 feet.[6]

f. The finding of a flint arrow-head under the scapula of an extinct bison in Kansas by Mr. H. T. Martin.[7]

We may not be able to rely absolutely on any one of these reputed finds; but taken together they are cumulative and produce a probability of man's existence in Pleistocene times.

10. Man had his origin probably in southern Asia. From this region, and not from Europe, were peopled the other continents and the islands of the seas. A people as advanced as many modern Indians may have reached America long before the Cro-Magnons had been able to dispossess the fierce Heidelbergers and Neanderthalers who had preoccupied Europe.

[2] DICKESON. Proc. Phila. Acad., **3**: 106. 1896.

[3] WITTER. Proc. Iowa Acad. Sci., **1890–1891**: 67.

[4] Op. cit.

[5] UDDEN. Iowa Geol. Surv., **11**: 261.

[6] PETERSON. Record of the Past, **2**: 26.

[7] Amer. Geol., **30**: 313.

11. There seems to be no good reason why some races of man might not, very early in the Pleistocene, have reached a physical development quite equal to that of today. Such was the case with the horses, the oxen, the bears, the dogs, and many other forms.

Dr. Hay's remarks were illustrated by lantern slide views of the deposits.

M. W. LYON, JR., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 511th regular and 38th annual meeting of the society was held at the New National Museum on April 17. After approving the reports of the secretary, treasurer, and auditing committee the society elected the following officers for the ensuing year: *President,* Mr. WILLIAM H. BABCOCK; *Vice-President,* Mr. FRANCIS LAFLESCHE; *Secretary,* Miss FRANCES DENSMORE; *Treasurer,* Mr. C. N. B. HEWITT; *Councillors,* Mr. E. T. WILLIAMS, Mr. NEIL M. JUDD, Dr. TRUMAN MICHELSON, Mr. FELIX NEUMANN, and Dr. I. M. CASANOWICZ.

Memorials to members of the society deceased during the past year were then presented. A sketch of the life of Gen. ELLIS SPEAR, an active member of the society, was read by Mr. W. H. BABCOCK. The memorial to Mr. S. M. GRONBERGER, an associate member, was prepared and presented by Mr. JAMES MOONEY, and that to Mr. J. D. McGUIRE, an honorary member, was prepared and read by Dr. J. W. FEWKES. Tributes to Prof. JOHANNES RANKE and Prof. GUSTAVE SCHWALBE of Germany, honorary members, were given by Dr. ALEŠ HRDLIČKA, and a review of the life and work of Sir EDWARD BURNETT TYLOR, a corresponding member of the society, was read by Dr. JOHN R. SWANTON; tributes to Dr. TYLOR being also given by Dr. TRUMAN MICHELSON and Dr. LEO J. FRACHTENBERG.

FRANCES DENSMORE, *Secretary.*

CONTENTS

Original Papers

Page

Physics.—A visibility equation derived from the Ives and Kingsbury new luminosity equation. Paul D. Foote 317

Genetics.—The control of the sex ratio. Oscar Riddle 319

Abstracts

Geology 357

Proceedings

The Biological Society of Washington 358

The Anthropological Society of Washington 360

VOL. VII

No. 12

JUNE 19, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII   JUNE 19, 1917   No. 12

MINERALOGY.—*Auricalcite from Big Cottonwood Canyon, Salt Lake County, Utah.* A. Ledoux, University of Brussels. (Communicated by T. L. Walker.)

The mineral aurichalcite was first given rank as a distinct species in 1839 by Böttiger. Prior to that time it was recognized as early as 1788 under the name "calamine verdâtre" by Patrin, who mentioned that this variety of calamine contained "une bonne quantité de cuivre."

On account of the character of the mineral, previous investigators have worked at a decided disadvantage in determining the crystal system to which this mineral belongs, and the writer has labored under some of the disadvantages that in the past prevented the most accurate determination of the crystal constants.

A brief résumé of the crystallographic work that has been done on the mineral follows:

In 1874 Des Cloizeaux[1] described aurichalcite as acicular crystals of undetermined form.

In 1890 Albin Belar[2] considered the mineral as monoclinic with $\beta = 0$ and $a : b : c = 1 : x : 0.7208$. He states that the plates of the mineral are parallel to the principal cleavage taken as 010, the side GH of the triangle (fig. 1) being the combination of 010 and 100, the hypotenuse GI being the edge between

[1] Manuel de Minéralogie, **2**: 183. 1874.

[2] *Ueber Aurichalcite.* Zeitschr. für Krystallographie, No. 17. 1890.

010 and a dome. Belar observed the following forms: (104), (101), (201), (301), (401), (501), (601).

In 1896 Prof. G. Cesàro[3] described fragmentary crystals found at Flémalle in Belgium. He considers the mineral as orthorhombic on account of its optical properties. The principal tabular cleavage was by him taken as the front pinacoid (100). The frequency of wedge-shaped tables is due to a pyramidal hemihedrism. In order to obtain simple symbols for the domes Professor Cesàro started from a unit brachydome much steeper than that of Belar and corresponding to

$$c = 8.71263.$$

In 1897 Prof. G. B. d'Achiardi[4] ascribed the wedgelike crystals of aurichalcite to twinning of simpler monoclinic individuals, the lateral faces of the wedges being contact faces of the twins. The following constants were determined:

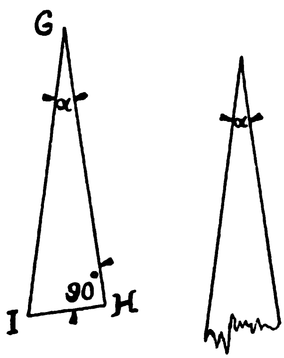

FIG. 1

$$a : b : c = x : 1 : 1.6574$$
$$\beta = 84° \ 15'.$$

In 1908 M. L. F. Navarro,[5] of Madrid, measured with the microscope five crystals of aurichalcite from Ondárroa, Vizcaya, Spain. The face-angles of the three-pinacoid measured on three crystals gave the following measurements:

$$(a) = 82° \ 34' \pm 11'$$
$$(b) = 80° \ 35' \pm 21'$$
$$(c) = 77° \ 55' \pm 16'$$

angles which may be regarded as α, β, and γ or their supple-

[3] *Description des Minéraux phosphatés, sulfatés, et carbonatés du Sol Belge.* Mém. de l'Acad. Roy. des Sciences, etc., de Belgique, Bruxelles, **53**: 1–134. 1897.

[4] *Aurichalcite de Campiglia Maritima et Valdaspar.* Atti Soc. Tosc. di Sci. Nat. Memori, **16**: 1–15. 1897–98.

[5] Bol. R. Soc. Esp. Hist. Nat. Madrid, pp. 117–119. February, 1908.

ments. Auricbalcite has thus been considered orthorhombic, monoclinic, and triclinic.

Professor A. Lacroix[6] agrees with Prof. Cesàro in regarding aurichalcite as orthorhombic. He suggests that Professor d' Achiardi in regarding the mineral as monoclinic on account of an extinction of 17° may have made his observations on plates seen obliquely to the cleavage. The aurichalcite from Chessy, France, occurs as needles without flattening, with parallel extinction, suggesting orthorhombic symmetry.

Chemical examination of aurichalcite from Utah has been made by Penfield,[7] who deduced the formula $2(Zn, Cu)CO_3.3(Zn, Cu)(OH)_2$. If Zn : Cu = 5 : 2, the theoretical composition is as following:

CO_2	16.14
CuO	20.79
ZnO	53.17
H_2O	9.90
	100.00

Penfield did not give any information about the geometrical properties of the material analysed.

The mineral aurichalcite is pale blue to pale green in color, appearing macroscopically to consist of delicate aggregates of bluish needles; under the microscope, however, the needles commonly appear as wedges with a very acute angle α. Sometimes the wedge has the form of a right-angled triangle, but generally the shortest side, opposite the angle α, is replaced by an irregular line (fig. 1).

On account of the uncertainty of the symmetry of aurichalcite, I thought it of some interest to make further investigation of its crystals. Some very fine specimens from Big Cottonwood Canyon, Salt Lake County, Utah, were placed at my disposal by the Royal Ontario Museum of Mineralogy. The structure is usually radial or plumose. To study the mineral it is first of all necessary to get simple individuals; these are most easily obtained by crushing an aggregate between two glass

[6] Minéralogie de la France et de ses colonies, **3**: 739. 1909.
[7] Amer. Journ. Sci., III, **41**: 106. 1891.

slides. One obtains then a great number of small individuals of various forms, the most common of which is triangular in outline (fig. 1). The angle α is very acute, while the angle GHI is 90°. In several individuals from Big Cottonwood Canyon the value of α is 19°, a value agreeing with that obtained by Professor Cesàro[8] on the crystals of Flémalle. Other forms observed on these specimens are shown in figure 2. Most of the

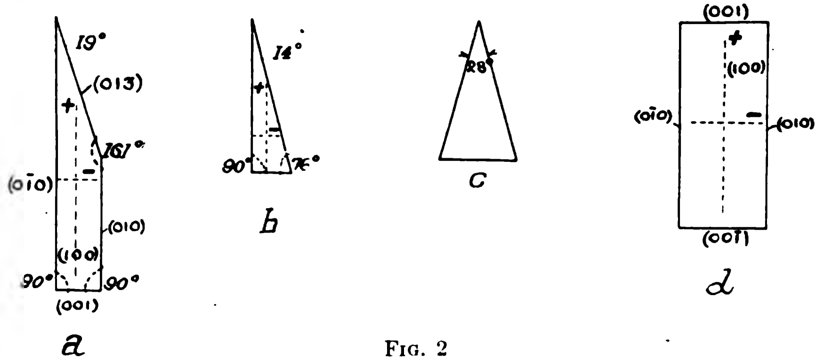

FIG. 2

individuals are cleavage plates with a contour of pinacoids and domes belonging to the zone (001) (010). If (0kl) is the notation of one of those domes, the angle α = (0kl$\wedge$010) may be deduced from the equation:

$$\frac{l}{k} = c. \tan \alpha$$

As the angle α = (013$\wedge$010) has the same value of 19° as that given by Professor Cesàro we may use the same parameter,

$$c = 8.71263$$
$$\log c = 0.94015.$$

Table 1 gives the different α angles observed on the crystals and the corresponding symbols of the domes; but the results are only approximate, as the angles were measured with the microscope.

[8] Loc. cit.

TABLE 1

ANGLES OBSERVED FOR AURICHALCITE AND THE CORRESPONDING SYMBOLS OF THE DOMES

α	$\log \frac{l}{k}$	$\frac{l}{k}$	$0\ k\ l$
6°	1.96177	0.9157	0 1 1
10°	0.18647	1.356	0 2 3
14°	0.33692	2.173	0 1 2
19°	0.45279	2.837	0 1 3
23°	0.53203	3.404	0 2 7
27°	0.59720	3.955	0 1 4
30°	0.70159	5.030	0 1 5
44°30′	0.93257	8.562	0 2 17

There are probably also rhombic pyramids elongated in the direction of the vertical axis with very short intercepts on the *a* axis. It is generally impossible to focus exactly these faces, and as a result the *a* parameter cannot be calculated, nor the symbols of the pyramidal faces. It sometimes happens that an individual of aurichalcite is lying on one of these pyramidal faces; the extinction angles and the observations in convergent light become then valueless for the determination of the crystal system.

As to the optical properties of the aurichalcite it may generally be noticed that the extinction is straight along the (010) (100) edge. The acute bisectrix is normal to the cleavage plate (100), which exhibits mean birefringence. The crystal plates are so small that it was impossible to measure the indices of refraction and the other optical properties.

MINERALOGY.—*The indices of refraction of analyzed rhodochrosite and siderite.*[1] EDGAR T. WHERRY, National Museum, and ESPER S. LARSEN, Geological Survey.

Rhodochrosite. The beautiful, transparent, crystallized rhodochrosite from the John Reed Mine, Alicante, Lake County, Colo., has been described by Dr. G. F. Kunz[2] who gave the FeO

[1] Published with permission of the Secretary of the Smithsonian Institution and the Director of the U. S. Geological Survey.

[2] Am. Journ. Sci., (3) **34**: 477. 1887.

content as 3.62 per cent, and the specific gravity 3.69, on the authority of J. B. Mackintosh. Prof. E. S. Dana states[3] that the angle $r \wedge r'$ is $73° 4\frac{1}{2}'$. In the course of the determination of the optical constants of minerals one of us (E. S. L.) desired to obtain the indices of refraction of the purest possible rhodochrosite and in order to confirm the composition of the mineral in this occurrence, a specimen (No. 86249) in the National Museum collection was analyzed (by E. T. Wherry). The results of the analysis were: $MnCO_3$ 95.72, $FeCO_3$ 1.87, $CaCO_3$ 0.50, $MgCO_3$ 0.68, gangue 0.82 per cent, sum 99.59 per cent. This represents a lower percentage of iron than previously reported, but undoubtedly the relative amounts of isomorphous constituents vary from one specimen to another. That this specimen is actually somewhat different from the previously described one is shown by the angle $r \wedge r'$, which, measured on cleavage planes, varies from 73° 10′ to 73° 20′, always exceeding the earlier measurement, and the specific gravity, which is 3.71, distinctly higher than that above quoted.

The indices of refraction were measured by E. S. Larsen by the immersion method. The index ϵ was measured directly, and checked by measuring the highest and the lowest indices on the very perfect cleavage pieces and computing the value of ϵ from the formula for the indicatrix

$$\frac{x^2}{\omega^2} + \frac{y^2}{\epsilon^2} = 1$$

knowing the cleavage angle and, hence, the angle of inclination of the section with the basal plane. The results were: $\omega = 1.817 \pm 0.003$, $\epsilon = 1.595 \pm 0.005$, measured directly; $\epsilon' = 1.699 \pm 0.003$ on the cleavage piece, hence, $\epsilon = 1.594 \pm 0.005$.

The indices of refraction of the rhombohedral carbonates are greatly affected by isomorphous replacements, but as in this case the total replacement is only about 3 per cent and as the calcium and magnesium carbonates, which lower the indices, are in such proportions as to compensate approximately the effect of the iron carbonate, which increases the indices (see below),

[3] DANA, E. S. System of Mineralogy, 6th ed., p. 279, 1892.

this specimen should yield indices almost identical with those of pure rhodochrosite, $MnCO_3$.

The indices of refraction of the Colorado rhodochrosite agree, in fact, closely with the values given by Winchell[4] and ϵ is slightly less than the value given by Ortloff[5] for a specimen containing $MnCO_3$ 93.08, $FeCO_3$ 7.12, $CaCO_3$ 0.27, which would be expected to yield a somewhat high result because of the $FeCO_3$ present. The author (E. S. L.) has measured ω on several other specimens of rhodochrosite, and found the values almost identical in all of them, as shown in Table 1.

TABLE 1

INDICES OF REFRACTION OF RHODOCHROSITE

	LAKE COUNTY, COLO.	CLIMAX, COLO.	OFERNEST, GERMANY	QUOTED, WINCHELL	QUOTED, ORTLOFF	INFERRED
$MnCO_3$.....	95.7 per cent	—	—	—	93.1 per cent	100 per cent
ω	1.817	1.817	1.818	1.82		1.818
ϵ	1.594			1.60	1.597	1.595

Siderite. Two measurements of the indices of refraction of analyzed specimens of fairly pure siderite are available in the literature. The nearly pure $FeCO_3$ from Camborne was found by Hutchinson[6] to have $\omega = 1.8724$, $\epsilon = 1.6338$, while the siderite from Wolfsberg, which is much higher in $MnCO_3$ and $MgCO_3$, is reported by Ortloff[7] to have $\omega = 1.9341$, $\epsilon = 1.6219$. These data are inconsistent; the purer specimen should have the higher indices, since the impurities $CaCO_3$, $MgCO_3$, and $MnCO_3$ all have considerably lower indices than $FeCO_3$. The authors have, therefore, checked the data by measurements on two specimens of recently analyzed siderite. These measurements agree very closely with the data of Hutchinson, so that we regard Ortloff's value for ω as undoubtedly in error, although his value for ϵ is satisfactory.

[4] WINCHELL, N. H., and A. N. Optical Mineralogy, p. 149, 1909.

[5] ORTLOFF, W. *Beitrag zur Kenntnis eutropischer Reihen.* Zeits. phys. Chem., **19**: 215. 1896.

[6] HUTCHINSON, A. *The chemical composition and optical characters of chalybite from Cornwall.* Min. Mag., **13**: 209. 1903.

[7] ORTLOFF, W. Loc. cit., pp. 215–6.

The compositions and indices of refraction of four siderites are given in Table 2 for comparison. The data for the siderite associated with the cryolite from Ivigtut, Greenland, and those of the mineral from the Spokane locality are new. The latter

TABLE 2

INDICES OF REFRACTION OF ANALYZED SPECIMENS OF SIDERITE

	GREENLAND[a]	SPOKANE[b]	CAMBORNE[c]	WOLFSBERG[d]	INFERRED
$FeCO_3$	93.49	93.16	98.43	77.32	100.00
$MnCO_3$	5.16	tr.	1.82	17.04	
$MgCO_3$	0.62	1.83	0.26	5.42	
$CaCO_3$	0.37	5.13	0.18	0.86	
Gangue	1.15				
Sp. gr.	3.94	3.84	3.937		3.96
ω	1.871	1.858	1.8724	[e]1.9341	1.875
ϵ	1.631	1.622	1.6338	1.6219	1.635

[a]Analysis and sp. gr. by E. T. W., optical data by E. S. L. U. S. Nat. Mus. Cat. No. 17571.

[b]Analysis by J. P. Maider, City Chemist of Spokane, made at the instance of Mr. Henry Fair and kindly furnished by Mr. L. P. Gratacap of the American Museum of Natural History of New York; the sp. gr. determination is by Mr. Gratacap, and the optical data by E. S. L.

[c]Hutchinson, loc. cit.

[d]Ortloff, loc. cit.

[e]This value must be in error as pointed out above.

occurrence will be described in a forthcoming number of the *American Mineralogist*. The probable error in the indices of refraction for these two new measurements does not exceed ±0.005.

GENETICS.—*The rôle of selection in evolution.*[1] W. E. CASTLE, Bussey Institution.

Up to the year 1900 those who believed in organic evolution almost without exception believed in selection as its efficient cause. Then came a period of doubt, inaugurated by DeVries' Mutation Theory and strongly supported by Johannsen's Pure Line Theory. In the minds of many biologists at the present time selection is an obsolete agency in evolution and an adequate explanation of evolution is to be found only in mutation and pure lines. I believe this to be a mistaken view, not because mutation and pure lines are false, but because their applicability is very limited as compared with the broad field of organic evolution. To universalize them is to hide the world by holding a small object close to the eye. For even if we concede the strongest possible claim for mutation as an agency in evolution, viz, that it produces all new and heritable variations, it is still unable to produce evolution without the aid of selection. The production of new variations produces no racial change unless those variations persist, but their persistence depends wholly upon selection. This is admitted by DeVries, the author of the mutation theory, but overlooked by many of those who have adopted the term mutation, as a scientific shibboleth.

But it is idle to enter upon a discussion of either selection or mutation without carefully defining these terms, since both are often used quite ambiguously, the latter in particular being used in several different senses, and so being a cause of misunderstanding where no genuine difference of view exists.

Ever since DeVries' original attack in 1900, it has become increasingly common among biologists to refer with disrespect to "Darwinian selection." But Darwin understood by selection any agency which would cause one organism to survive rather than another, and it is not clear that any theory of evolution can dispense with such an agency. Since more organisms are born than can survive, some must perish. In a state of

[1] A lecture delivered before the Washington Academy of Sciences, April 13, 1917.

nature, that is, in a state of affairs not actively controlled by man, those creatures survive which are best adapted to their surroundings. This is what Darwin meant by "natural selection." Among organisms under the immediate control of man, as the cultivated plants and domesticated animals, where the determination of what individuals shall become parents rests with man, Darwin recognized the occurrence of "artificial selection."

Any legitimate attack on Darwin's views of selection must deal either with natural selection or with artificial selection. But when "Darwinian selection" is mentioned as a term of reproach, the attack is really directed neither against natural selection nor against artificial selection, nor against any other conceivable form of selection, but against one of Darwin's views as to the nature of variability. Darwin recognized two sorts of heritable variations, (1) those which are purely quantitative, plus or minus, as compared with the prevailing racial condition, and (2) those which are wholly different from the prevailing condition. The former we may call "fluctuations," adopting the convenient term of DeVries. The latter Darwin often called "sports." Bateson has called them discontinuous variations, and DeVries calls them mutations. Darwin believed that evolution might result either from the systematic and repeated selection of fluctuations or from the propagation of sports. DeVries doubts whether the systematic selection of fluctuations amounts to much in an evolutionary way, and Johannsen has denied to it any evolutionary effect whatever, on the ground that fluctuations are not inherited. Darwin assigned to the selection of fluctuations a major part in evolution, DeVries assigned to it a minor part, and Johannsen allows it no part in evolution. As regards sports, Darwin assigned to their selection a minor part in evolution (chiefly among cultivated plants and domestic animals); DeVries ascribed to a particular kind of sports (his "mutations") a major part in evolution; and Johannsen ascribes an exclusive part in evolution to a type of variation which would include both Darwin's sports and DeVries' mutations and then some. Johannsen has indeed made a new classification

of variations which is both logical and sound, but which has resulted in some confusion owing to efforts to combine it with earlier classifications. He classifies variations into those which are inherited (genotypic) and those which are not inherited (phenotypic). No objection can be made to this classification except that it raises new difficulties and solves none. For how is one to distinguish a phenotypic from a genotypic variation? Only by trying them out. A variation which is inherited is genotypic; one which is not inherited is phenotypic. Since there is no other way then actual experiment by which to distinguish genotypic from phenotypic variations, we acquire only a new set of synonyms for inherited and non-inherited, a thing for which there was no urgent need.

Attempts to combine the classifications of variations made respectively by Darwin, by DeVries, and by Johannsen have resulted in serious confusion which is largely responsible for the apparently contradictory views held at present concerning selection. There really is no diversity of view concerning selection but only concerning the nature of the material that it acts upon (viz., variations).

To complicate the situation still farther we have the discovery of Mendelian unit-characters which introduces a new uncertainty. Are these unit-characters fluctuations or sports? Do they arise solely by mutation or also by the cumulation of fluctuations? These are vital but perplexing questions. As matters stand concerning terminology, we have the term "sport," introduced by Darwin but now largely discarded, meaning any discontinuous, striking, suddenly appearing variation, known to be strongly inherited. Some of the examples cited by Darwin, such as the Ancon sheep, obviously involve Mendelian unit-characters.

The term mutant as used by DeVries signifies much the same as Darwin's term sport but involves a particular conception of the circumstances and manner of its origin which is not involved in Darwin's term. Some of DeVries' mutants of the evening primrose involve Mendelian unit-characters, as for example his dwarf mutant (*nanella*), while others such as *gigas* do not.

The latter involves a double representation of every chromosome in the cell nucleus; the *lata* mutant involves the presence of a single extra chromosome. What chromosome changes, if any, are involved in other of DeVries' mutants which do not Mendelize is unknown. Morgan has shown that in Drosophila a unit-character change almost certainly involves a change in a definitely localized part of a single chromosome. But he applies the term mutation to each unit-character variation of Drosophila, of which he has observed over a hundred. Some of these are not at all striking, involving only a slight change in the shape, size, venation, or carriage of the wing, which might easily be overlooked by the ordinary observer. Many of them also fluctuate. Hence it is obvious that Morgan's use of the term mutation is very different from that of DeVries, its originator. To Morgan, mutation as illustrated in Drosophila is simply change by a unit-character. With this conception of mutation, Morgan attempts to combine the genotype conception of Johannsen. He regards unit-character variations as the only kind of genotypic variations and these as fluctuating (if at all) only through the interaction of other unit-characters, each one by itself being incapable of fluctuation.

It will be observed that as regards the term mutation, we have a very confused state of terminology which results in much discussion at cross-purposes, because persons using the same term have different things in mind.

But in this discussion, however confused its terminology, there are really involved two contrasted sets of general ideas, two alternative lines of explanation of evolutionary change, one favored by Darwin, the other offered as a substitute by DeVries and accepted by Johannsen and Morgan. We may briefly outline them as follows:

Darwin	DeVries
1. New types are for the most part created gradually.	1. New types are created only abruptly.
2. New types are for the most part plastic.	2. New types are fully stable.
3. One evolutionary change follows upon and is made possible by another.	3. One evolutionary change has no necessary relation to another.

4. Natural selection determines what classes of variations shall survive and, in consequence, what shall be the variable material subjected to selection in the next generation.	4. Natural selection determines only what classes of variations shall survive, and exercises no influence on the subsequent variability of the race.
5. The further evolution of our domestic animals and cultivated plants (and of man himself) is to some extent controllable because we can by selection influence the variability of later generations.	5. Evolution is beyond our control except as we discover and isolate variations.

These two sets of contrasted views remind us somewhat of the theological ideas of free-will and predestination respectively, which resemblance will account for the preferences of some biologists but will not prove which is right and which is wrong. This is wholly a matter for evidence. But what conclusion one reaches will depend much upon what sort of evidence he studies. Paleontology, geographical distribution, classification, and experimental breeding, all present evidence which must be weighed before a safe verdict can be framed.

Paleontology, the study of the actual historical records of evolution found in the rocks, indicates in the case of the most complete series of fossils, as for example of the horse, the camel, and the rhinoceros, that the evolution of these types was a gradual process, though of course their appearance in particular continents may have been abrupt, owing to migration. It indicates further that these and other types, when they first appeared, were plastic, and generalized and varied in many different ways, most of the variations later disappearing and leaving only a favored few lines of specialized survivors. It shows too that one variation paved the way to another. The five-toed horse first becomes four-toed, then three-toed, then one-toed. There is no mutation from five-toed to one-toed, nor from the size of a fox to that of a draft horse. As to natural selection, paleontology is silent, because the causes of extinction are unknown. But on the whole the weighty evidence of pale-

ontology supports the view that evolution as an age long process has been gradual and progressive, not abrupt and unguided.

Geographical distribution and classification favor the same idea. Related species are most often found in contiguous territory. Species not closely related are commonly far separated in space or have been long separated in time. Nothing indicates that of two related species one has sprung suddenly from the other. They are not distinguished from each other, as a sport from its parent form, by some single Mendelian unit-character, but they differ morphologically by a large number of quantitative differences, and physiologically they differ to such an extent that frequently they will not interbreed when brought together even though their morphological differences are small, or they will produce sterile hybrids, or those of a blended, intermediate character. In all these particulars they show that they have not diverged by mutation, either in the sense of De Vries or in that of Morgan, but by a gradual progressive process.

Finally we come to the evidence from experimental breeding. Some say that this is the only legitimate evidence as regards the method of evolution because it alone is experimental. I should be the last to deny its importance because I have devoted much time to its pursuit in the firm conviction that it could yield valuable evidence, but frankness compels one to admit that this method of study, like all the others, has limitations of its own. The experimental breeder can study a few successive generations with an intensiveness that is possible by no other method, but his glimpses of evolution at work are momentary as compared with the studies of the paleontologist. He can witness the production of new sorts but it is doubtful whether any man has witnessed the contemporary production of a new species, in the sense of the paleontologist and the student of geographical distribution. Evolution is undoubtedly at work all the time, but the breeder is not always in a position to say just what is happening. It takes a succession of views in a motion picture to show what objects are stationary and what are moving, and the breeder's view of the evolutionary process often fails to reveal which is which.

On the other hand, the experimental breeder, though he lacks perspective, is dealing with the actual material concerned in organic evolution. He can see and handle it and observe it change under his hands, as no other student of evolution can. But the changes which he observes taking place must be correctly interpreted if valid conclusions are to be reached concerning the general process of evolution. At present experimental breeders are divided in their views. The very same facts are interpreted by some as indicating an orderly progress toward definite end results, and by others as nothing but haphazard unrelated chance occurrences. Just now the latter method of interpretation, embodied in the mutation theory, is very popular among experimental breeders, although it has few adherents among students of paleontology, classification, or geographical distribution.

The principal tools of the experimental breeder are hybridization and selection. All are agreed that hybridization (using the term in its broadest sense) is, in the hands of the breeder, a very potent agency in producing variability, upon which selection may then be brought to bear for the production of new or modified types. Lotsy even goes so far as to suggest that all genetic variability is the result of hybridization, but this is flatly disproved by observations of Johannsen who reports the occurrence of mutations in genotypically pure lines of beans, as also by the remarkable series of variations observed by Morgan in an inbred race of Drosophila.

As regards the action of selection, the most widely divergent views are held by experimental breeders. The mutationists hold that it can do nothing but isolate variations which may sporadically put in an appearance or which may by hybridization be brought together into new combinations. Those who differ from them, and whom they call selectionists, maintain that selection can accomplish more than the mere isolation of variations because it can, by a series of selections, influence further variability. I confess myself an adherent of this at present somewhat unpopular view. I hold it, not because Darwin held it, nor merely because paleontologists, systematists,

and students of geographical distribution in general favor it, nor because DeVries and Johannsen have attacked it, but because the facts of experimental breeding, as I understand them, prove it.

For DeVries may be claimed the merit of having first systematically set about testing the effects of selection by actual experiment. His methodical selections for many years in succession of maize, buttercups, striped flowers, and four-leaved clover will long be remembered, but they fall far short of conclusiveness because they were not continued long enough to show whether selection had attained all that was attainable under existing variability or whether further variation in the direction of selection would occur, and because DeVries' cultures were not sufficiently guarded from hybridization which might conceivably influence the result. These necessary precautions were fully met by Johannsen, who in the case of beans, which are self fertilizing but show fluctuating variation in the size of the seed, proved that selection generation after generation in a particular direction may be without result, so far as any change in average seed size is concerned. Cases of this sort involve "pure lines," those which are devoid of genetic variation to any appreciable extent in the character studied, size of seed. But in other cases, as where Johannsen made his size selections from a field crop harvested from many different plants, he found that average size was influenced by selection, which he reasonably explains on the ground that the material from which selection was made consisted of a mixture of pure lines genetically distinct. The correctness of Johannsen's conclusion has been repeatedly verified in the case of other self-fertilizing plants such as wheat and oats. Attempts were at once made to generalize Johannsen's brilliant demonstration of the principle of pure lines in the following ways:

1. Since a line of beans long self-fertilized is devoid of genetic variation in seed size, self-fertilization, if long enough continued, will produce lines genetically pure as regards *all* characters. Selection can not bring about modification of such pure lines. In respect to this generalization it may be said that it remains to

be shown that beans are as devoid of genetic variation in other particulars as they are in seed size, which the argument assumes to be true. Further, if various pure lines of beans have come into existence by an evolutionary process (descent from a common ancestor, with modification) it is evident that differences must have arisen which did not originally exist. Suppose we grant Johannsen's (unproved) contention that such differences arise by mutation only. If they arise in this way (or in any other way whatsoever), selection can isolate them, and if they are at all frequent in occurrence, selection can be continuously effective in producing racial changes. It would all come down then to a question of how frequent mutations are in a particular case. Johannsen concedes their occurrence even in beans. It may well be that in some organisms they are commoner than in others and that in beans they happen to be particularly infrequent.

2. Johannsen's case has been further generalized to include *all* self-fertilizing organisms, which are supposed to fall automatically into pure lines (i.e., those devoid of genetic variation) as regards all characters. This too requires proof, but has been found to be a safe working hypothesis in the case of cereals, tobacco, peas, and other economic crops, in the attempted improvement of which selection of fluctuations, unless preceded by hybridization may be regarded as a waste of time, for the reason that genetic variation is so rare under continuous self-fertilization that the breeder will obtain variation much more quickly by resorting to hybridization.

3. Further, it has been argued that if cross fertilization alone interferes with the automatic production of pure lines, then any organism which dispenses with fertilization altogether, reproducing asexually, must *ipso facto* constitute a pure line. Jennings sought to test out this conclusion by experiment. He selected size variations in Paramecium which reproduces by fission, with success in the case of mass cultures of unknown origin, but without success in the case of cultures made from single individuals. This was regarded as strong confirmation of the pure line principle until Calkins and Gregory, repeating the experiment on ex-conjugants, were unable to support it. Then

Jennings, selecting a new species of Protozoa, more favorable for precise quantitative observation, also obtained a different result. He now found that among the observed fluctuations in size, those of a genetic character were included, so that by repeated selection races could be produced which were progressively larger or smaller, rougher or smoother. This is fully in harmony with the observations of Stout who found that variations in Coleus arising in asexual propagation were capable of further propagation. It also harmonizes with the observation of Shamel as regards the occurrence in citrous fruits of bud variations which are important enough to warrant propagation in economic work; and further, with Winkler's clear demonstration of the occurrence in the tomato and the night-shade of *gigas* like mutations, arising first in single somatic cells, which asexually propagated produce entire plants of a new type which then are self-perpetuating by seed. We also have the observations of East that in the asexual propagation of the potato occasional bud variations may occur which are similar in nature to unit-character variations in reproduction by seed. It is accordingly clear that the pure-line principle does not apply without exception to asexually reproducing organisms any more than it does to self-fertilizing ones. It is true, however, that genetic variations are much less common among such organisms than among those produced by cross-fertilization. Herein lies the justification of present agricultural practice in the breeding of self-fertilized cereals, and of horticultural practice in the propagation by grafts, runners, layers, etc., of superior individual plants.

4. Attempts to extend the pure line principle to organisms which are not self-fertilizing (and this includes all the domestic animals and many cultivated plants) have met with small success. Morgan indeed assumes that it applies to his races of Drosophila up to a certain point, the point at which mutation begins, but the mutations which he recognizes are so numerous, so minute in many cases, and so fluctuating in others, that it becomes a question whether his "mutations" are not just ordinary heritable variations. Morgan would undoubtedly admit this since he claims that *all* heritable variations arise as mutations,

but this is simply juggling with names, giving a new meaning to the word mutation in order to justify a sweeping generalization otherwise untenable.

The test of a pure line is its freedom from any genetic variation, so that selection cannot modify the racial mean as regards any character. As soon as any race of animals or plants changes in response to selection, it must be forthwith excluded from the category of pure lines. The consequence is that no case of a pure line among animals has yet been demonstrated. Nevertheless the "*principle* of the pure line" is in some way or other supposed by the followers of Johannsen to confer on even the higher animals a limited liability to modification in consequence of selection.

Thus Pearl having been entrusted in 1908 with a selection experiment for increase of egg production in Plymouth Rock fowls, an experiment which had already been in progress for nine years, decided after a study of the records kept by his predecessor that no improvement whatever had up to that time been made and further that none probably could be made since individual wild birds probably lay, under favorable conditions, as many eggs as their best tame relatives. This reasoning was strictly in accordance with the "pure line principle" and was in fact based on it.

Later by changing somewhat the basis of selection, so as to rank his animals on the basis of their progenies' performance as well as their own, Pearl found that he could considerably increase the flock average. Yet he still maintains that he has only *more* good birds not *better* ones, than when the experiment began, and in loyalty to the pure line principle he has no expectation of obtaining better ones in the future, since he already has and has had all along the *ne plus ultra* sort. One less devoted than Pearl to a generalization of the pure line doctrine would continue hopefully the effort to produce a *better* fowl as well as to produce more good ones. For the function of egg-production admittedly depends upon many physiological factors (as well as several external ones). These physiological factors must many of them be independently variable and to some extent independ-

ently heritable. Variation in one or more of these factors (by mutation or otherwise) would undoubtedly influence the total productiveness, and the probability of the occurrence of a mutation would increase with the number of factors involved. So that even one formally committed to the pure line doctrine, but admitting as Johannsen does that mutations do occasionally occur in pure lines, might hopefully continue to look for improvement in the standard of egg-production. No other method of detecting and utilizing a favorable variation, when it does occur, can be suggested than the very method of methodical and persistent selection against which the pure line advocates direct such vigorous attacks.

Morgan is a formal adherent of the pure line doctrine, but pragmatically a selectionist for he admits the great progress made in the improvement of domestic animals and plants by selection, and even that his own mutants of Drosophila fluctuate and yield modified forms in response to methodical selection, as for example the bar-eyed mutant, subjected with success to plus and minus selection by Zeleny. But he attempts to explain these results in harmony with the pure line principle by assuming that, whenever a modification is observed in any character, this is due to a mutation, and if a graded series of modifications is obtained, as in the plus and minus selected bar-eyed Drosophila, this is due to a multiplicity of mutating factors whose action on the chief factor concerned is purely incidental. On this view, however, the attainment of a completely homozygous condition on the part of all factors (if all are indeed Mendelian) would put an end to genetic variability, and selection would then cease to produce effects. Such a completely stable condition has, however, rarely been demonstrated. One case is reported by MacDowell, that of a race of Drosophila with an extra number of thoracic bristles. The average number of bristles was increased by selection for six generations but then showed no further increase and could not subsequently be changed either upward or downward by further selection. The race had apparently become a "pure line" for bristle number.

In the case of certain characters in guinea-pigs I have repeatedly attempted modification of a racial character by selection within an inbred race, without success. Thus a very dark form of Himalayan albino, after a certain amount of improvement by selection, could not be further darkened to any appreciable extent. A race selected simultaneously for large size and for small size showed so little change that the experiment was abandoned after a few generations. No indication was forthcoming that we could thus ever approach in size either the small wild *Cavia Cutleri* of Peru, or the large races of guinea-pig kept in captivity by the natives of the same region. Yet evolution had in some way evidently produced these divergent conditions from a single original source. The changes were probably too slow to be observable in the life time of one observer.

On the other hand, certain characters of guinea-pigs, rabbits, and rats have been found to respond readily to selection in a particular direction. This is notably true of color patterns which involve white spotting. A selection experiment with hooded rats selected simultaneously in plus and minus directions has produced one race which is black all over except a white patch of variable size underneath, and another race which is white all over except for the top of the head and the back of the neck, which are black. The races do not overlap at all and have not done so for many generations, though they still continue to diverge from each other as a result of continued selection.

In similar experiments with Dutch marked rabbits it has been found possible by selection to increase or decrease the amount of white at will. In a series of such rabbits ranging from nearly all black to nearly all white, stages far enough apart to be certainly identifiable behave as Mendelian allelomorphs in crosses, but regularly emerge from such crosses in a slightly modified form, the whiter stages having been darkened and conversely the darker stages whitened. The principle of the pure line manifestly does not apply to these cases. White spotting is apparently a character which from its nature fluctuates constantly, such fluctuations having, to some extent at least, a genetic basis, since continuous selection invariably produces a

modified race. Even in wild species, such as the skunks, white-spotting is manifestly a variable character, which no doubt will respond to the selective efforts of our skunk farmers, who desire an all-black race. Why white-spotting should be a less stable character genetically than some others, it is impossible to say, but the fact is beyond question. Morgan has suggested that in general the genetic basis of a Mendelian character may be a single molecule, and gives this as a reason for believing in its constancy. But white spotting can hardly fall in with this conception. It seems to me more probably due to a quantitative deficiency in the germ of some substance which normally finds its way into all epidermal cells of the body and which is responsible for the development in them of melanin pigment. Greater and greater deficiencies of this substance cause more and more extensive white areas.

Complete or total albinism behaves very differently. It results from a complete change in some color factor which may well be a simple molecule since it appears to be incapable either of contamination in crosses or of modification under selection. Nevertheless the color factor (molecule or whatever it may be) evidently is not so simple but that it can assume at least four mutually allelomorphic forms, as shown for the guinea-pig by Wright, a like number of allelomorphs, though not their exact equivalents, being known also in the rabbit.

As regards the agouti factor in mice, rabbits, and guinea-pigs, this too may assume several different allelomorphic conditions, though it is not certain that any one of these fluctuates or can be modified other than by associating with it unrelated genetic factors.

The divergent conclusions which students of genetics have reached concerning the stability of Mendelian genes and the consequent effects of selection for their modification are probably due in part to the particular choices which they have made of test cases. A study of albinism alone would lead one to believe in the fixity and constancy of Mendelian genes and the impossibility of modifying them by selection. A study of white spotting leaves one with the unshakable conviction that this form of

gene is plastic and yields readily to selection. Where only genes of the former sort are involved, the principle of the pure line is applicable; where genes of the latter sort are involved, it is not applicable. The divergent results obtained by Jennings when dealing with Paramecium and when dealing with Difflugia indicate that among asexually reproducing organisms, also, genes are involved, some of which are stable, some of which are not. Accordingly, what conclusion we reach as to the applicability of the pure line theory in the breeding of animals and plants will depend upon how common we find stable and plastic genes respectively to be, and in what sorts of variations they are involved.

My own opinion, based upon a study through many years of a variety of inherited characters in the smaller mammals, inclines to the view that in such animals very few characters can safely be referred to the agency of perfectly stable genes. Even in color characters, probably the simplest as well as the most studied of inherited characters, there is much fluctuation which yields substantial results to selection by the discriminating breeder. The yellows are not all of one shade, nor the blacks of equal depth. The golden yellow of the Guernsey cow is very different from the fawn of the Jersey or the dark red of the Devon. Yet all are yellows, allelomorphs of black, but each is selected for a different standard to which the breeder must adhere very carefully in his selections, if he wishes to win prizes or sell breeding stock.

When it comes to size and shape and that consistent interrelation of parts which the breeder calls "conformation," stable genes cannot be detected. Crosses produce blends as regards size and shape, and conformation is completely dissipated by a cross. That is why the breeder is so reluctant to resort to an outcross unless he is engaged merely in meat or wool production and is not attempting to breed to a type. *Aside from color there are very few valued economic characters in our domestic animals which are not inherited after the manner of blends.*

Weight of carcass, quality of wool, milk production in cattle, egg production in fowls—all these are blending characters which

in later generations show either no segregation or imperfect segregation (fowls, Pearl[2]). I do not say that in these cases no Mendelian inheritance is involved, but merely that no stable genes are in evidence, nothing that would preclude the probable effective use of selection in maintaining or raising breed standards.

If we turn from the breeding of animals, in which manifestly the pure line principle has little applicability, to the breeding of plants other than those which are self-fertilized, we again find that this principle has a very limited applicability. Probably the most valuable open pollinated field crop in cultivation is maize. But a pure line of maize is not known to exist. An experiment which should have lead to the production of pure lines, if such a thing were attainable in maize, has been in progress at the University of Illinois for the past twenty years. Selection has been made for increased and for decreased protein content of the grain, and also for both increased and decreased oil-content, with the result that steady progress in the direction of selection has in every case been made. The high protein strain now contains twice as much protein as the low protein strain; and the high oil strain contains four times as much oil as the low oil strain. The divergence of the selected lines from each other is not now as rapid as at first but it still continues steadily, with no indication that it is soon to cease, as must be the case if only stable genes were involved.

Those characters in maize which directly affect the yield, such as size of plant, or of the grain which it bears, are blending in inheritance and show imperfect segregation subsequently. They are probably all of them quite as amenable to selection as the oil content and protein content of the seed, experimented upon in Illinois.

[2] It is true that Pearl (1912) has described fecundity in fowls as "typically Mendelian" in heredity but his figures show that in crosses between Barred Rocks and Cornish Indian Games, the average fecundity of the F_1 birds is in both the reciprocal crosses intermediate between that of the respective parent races though nearer the racial average of the sire, which supports his contention that a sex-linked gene is involved, but shows also that this is not the only factor involved. Back-crosses of F_1 of both sexes with the pure races give evidence of further blending (or imperfect segregation) on the part of the non-sex-linked factor or factors.

Finally, as evidence that even in self-fertilized plants the pure line principle may be inapplicable because of the existence of genes which are plastic, let me cite a very extensive and carefully executed piece of work on garden peas done by Hoshino. He studied the behavior of flowering time, and showed that its inheritance involves a Mendelian gene coupled with flower color (white or red). The inheritance of flowering time is intermediate, but F_1 is closer to the late than to the early parent in this character. Segregation is imperfect in F_2 with a range practically all the way from the early to the late parent, but not transgressing this range. F_3 and F_4 families from self-fertilized parents are in many cases quite variable but others are no more variable than the pure parental varieties and so may be treated as practically "constant." A study of the average flowering time of each of the 230 "constant" F_4 families shows that these fall into three main groups, some falling into a *modified early* group, not quite so early as the early parent, others falling into a *modified late* group, not quite so late as the original late parent, but most of all falling into an intermediate group occupying the region midway between the parent varieties in flowering time. Considered all together, the F_4 families "constant" for flowering time form an almost uninterrupted series of conditions connecting the respective parental conditions seen in the early flowering and in the late flowering race.

These observations show the existence of a gene for flowering time in peas which is decidedly plastic. That a gene actually exists is shown by its coupling with flower color. That it is plastic is shown by the fact that it emerges from the cross nearly always in a modified form. When the possibility of modification has been continued as long as the F_4 generation, the majority of the "constant" families are found in the intermediate or middle group. The plasticity is here shown in a tendency of the contrasted genes to blend into one of intermediate character. It is also shown in data given by Hoshino as to flowering time in parent individuals and their offspring in the late flowering variety. Although this variety is treated by Hoshino as a "pure line," it is evident that within this line itself the later flowering in-

dividuals have later flowering offspring and *vice versa*. In other words selection within this supposed "pure line" is evidently effective. Accordingly either the gene here involved is plastic or the supposed pure line is not pure.

From the various lines of evidence which have been cited (and I might have cited many more) it is clear that the pure line principle, valid as a working hypothesis for seed size in beans and for certain morphological characters in self-fertilized cereals, does not fit in with the observed facts as regards the effects of selection in the majority of the domesticated animals and cultivated plants, nor even with the behavior of certain characters in self-fertilized plants and asexually propagated animals. In the case of such characters as white spotting in mammals, it is evident that a change in the mean of the character in a particular direction in consequence of selection actually displaces in the direction of selection the center of gravity of variation, so that in a very true sense selection makes possible further variation in that same direction. The same is probably true as regards protein content and oil content in the Illinois corn experiment. It is doubtful whether, outside of that particular experiment, maize with as high a protein content as 15 per cent has ever been observed, or maize with as high an oil content as 8.5 per cent. It is not then a misuse of terms to say that the selection has in this case been the *cause* of further variation in the direction of selection and so an agency in the progressive evolution of a new type.

If this is true concerning a single character under experimental study for a period of twenty generations, may it not also be true of entire organisms and groups of organisms subjected to keen competition with all other organisms in a struggle for existence which has continued for millions of generations? If there are characters which are plastic under artificial selection, why need we be skeptical about the plasticity of organisms subjected to natural selection? If artificial selection can, in the brief span of a man's life time, mould a character steadily in a particular direction, why may not natural selection in unlimited time also cause progressive evolution in directions useful to the

organism? I am not ready to say that natural selection is proved as the method *par excellence* of evolution, but I am not ready to abandon it as the most reasonable explanation of evolution until something better supported than the mutation theory is offered as a substitute for it. At the same time the fact should be emphasized that biology has benefited greatly from the investigation and the discussion initiated by the mutation theory. Even though the mutation theory cannot be accepted as a general theory of evolution it has done us great good in dispelling or clarifying the hazy notions which formerly existed as to what natural selection could accomplish. Selection, whether natural or artificial, is, as the mutation theory rightly holds, primarily an agency for the elimination of variations, not for their production. It can only act on variations actually existing, and while it can, I believe, continue and extend variation already initiated by shifting in the direction of selection the center of gravity of variation, it cannot initiate new lines of variation. It cannot change a vertebrate into something else nor something else into a vertebrate. It is limited to the modification of existing types of organisms, and to their modification in directions in which they show a tendency spontaneously to vary.

BIBLIOGRAPHY

CASTLE, W. E., 1916. Genetics and Eugenics. Harvard Univ. Press.

HOSHINO, Y., 1915. On the inheritance of the flowering time in peas and rice. Journ. Col. Agr. Tohoku Imp. Univ., vol. 6.

JOHANNSEN, W., 1909. Elemente der exakten Erblichkeitslehre. Jena.

MACDOWELL, E. C., 1915. Bristle inheritance in Drosophila. Journ. Exp. Zool., Vol., 15.

MORGAN, T. H., 1916. A critique of the theory of evolution. Princeton Univ. Press.

PEARL, R., 1912. The mode of inheritance of fecundity in the domestic fowl. Journ. Exp. Zool., vol. 13.

PEARL R., 1916. Fecundity in the domestic fowl and the selection problem. Amer. Ass. Nat., Vol. 50.

SCOTT, W. B., 1917. The theory of evolution. New York.

SMITH, L. H., 1912. Altering the composition of Indian corn by seed selection. Journ. Indust. Eng. Chem., vol. 4.

DEVRIES, H., 1900–1903. Die Mutationstheorie. Leipzig.

WRIGHT, S., 1916. Studies of inheritance in guinea-pigs and rats. Carnegie Inst. Wash., Pub. 241.

ZOOLOGY.—*A revision of the recent genera of the crinoid family Bourgueticrinidae, with the description of a new genus.*[1] AUSTIN H. CLARK, National Museum.

Of all the families of stalked crinoids represented in the recent seas the Bourgueticrinidae is the most universally distributed, occurring in all the oceans and ranging from 112 meters (62 fathoms) or less to a depth of 4842 meters (2690 fathoms), the greatest depth at which stalked crinoids have been found.

The genus *Metacrinus*, now dominant in the East Indies and ranging from southern Australia and Tasmania to southern Japan, includes about 25 species; but aside from this genus the Bourgueticrinidae with its 30 species is more numerously represented than all the other stalked families together.

Heretofore the recent species of Bourgueticrinidae have been grouped in two genera, *Rhizocrinus* and *Bathycrinus*, though it has long been evident that such a disposition was far from satisfactory; especially has this been the case since the discovery of the species of *Monachocrinus*, which have the general appearance of the species of one of the genera (*Bathycrinus*), but the detailed structure of those of the other (*Rhizocrinus*).

The recent species of the Bourgueticrinidae fall into six natural groups, which are differentiated as shown in the following key:

Key to the Recent Genera belonging to the Family Bourgueticrinidae

a^1 The third, sixth, and ninth brachials (the fifth, eighth, and eleventh ossicles from the radials) have a muscular articulation on either end; basals always fused into a solid ring which is broader than long, cylindrical or short truncated-conical; ten arms

b^1 The distal edges of the brachials are produced, overlapping the bases of the succeeding brachials, so that the dorsal profile of the arms is serrate; the IBr_2 (axillary) is markedly broader than long, distinctly shorter than the IBr_1 *Bathycrinus*.

b^2 The distal edges of the brachials are not produced, so that the dorsal profile of the arms is smooth; the IBr_2 (axillary) is little, if any, broader than long, and is about as long as the IBr_1 *Ilycrinus*.

[1] Published with the permission of the Secretary of the Smithsonian Institution.

a^2 All the post-radial ossicles are united in pairs by non-muscular articulation; the basals are separate, or are fused into a solid ring which is truncated conical, always longer than broad

b^1 Ten (or twelve) arms, the second post-radial ossicle being axillary

Monachocrinus.

b^2 Five undivided arms

c^1 No sutures visible between the basals; the basals are solidly welded into a single conical ossicle

Rhizocrinus.

c^2 Basals always separated by distinct sutures

d^1 Column comparatively slender, the longer columnals being at least twice as long as broad; calyx distinctly conical

Bythocrinus.

d^2 Column very stout, the longer columnals being but little longer than broad; calyx nearly or quite cylindrical

Democrinus.

Bathycrinus Wyville Thomson.

Bathycrinus Wyville Thomson, Proc. Roy. Soc. Edinburgh, **7,** 1872, p. 772 (genotype *B. gracilis*, sp. nov.).

Geographical Range.—Mid-equatorial Atlantic and northwestward to the coast of Virginia and Maryland (as far as 38° 20′ N. lat.), and northward to the latitude of the northern part of the Bay of Biscay (47° 38′ N. lat.); eastern part of the Bay of Bengal, east of the northern end of Sumatra; mid-Pacific between Oceania and America (from 0° 3′.4 to 9° 57′ N. lat.).

Bathymetrical Range.—From 1629 to 4842 meters (905 to 2690 fathoms).

Thermal Range.—From 34°.3 to 36°.8 Fahr. (all but one of the records are between 36°.5 and 36°.8).

Included Species.—*Bathycrinus aldrichianus* Wyville Thomson, *Bathycrinus equatorialis* A. H. Clark, *Bathycrinus gracilis* Wyville Thomson, *Bathycrinus pacificus* A. H. Clark, *Bathycrinus serratus* A. H. Clark, *Bathycrinus sibogae* A. H. Clark, and *Bathycrinus woodmasoni* A. H. Clark.

Ilycrinus Danielssen and Koren.

Ilycrinus Danielssen and Koren, Nyt Magasin for Naturvidenskaberne, **23,** 1877, 3 die Hefte, p. 45 (genotype *I. carpenterii*, sp. nov.)

Pterocrinus (Wyville Thomson, MS.) P. H. Carpenter, "Challenger" Reports, Zoology, **11,** 1884, p. 242, 243 (genotype *Bathycrinus aldrichianus* P. H. Carpenter, 1884 [not of Wyville Thomson, 1878] = *Bathycrinus australis* A. H. Clark, 1907).

Geographical Range.—Antarctic regions, from west of the Crozet Islands to Enderby Land; extreme north Pacific from the Commander

Islands to between Sitka and the Columbia River; the cold deep water between Norway and Iceland, and northward.

Bathymetrical Range.—From 1337 to 4636 meters (743 to 2575 fathoms).

Thermal Range.—From 30°.9 Fahr. and −1°.6C. to 36°.6. Fahr.

Included Species.—*Ilycrinus australis* (A. H. Clark), *Ilycrinus carpenterii* Danielssen and Koren, and *Ilycrinus complanatus* (A. H. Clark).

Monachocrinus, gen. nov.

Monachocrinus A. H. Clark, Eastman's translation of Zittel's Palaeontology, 1913, p. 230.—A. H. Clark, Internationale Revue gesamten Hydrobiologie und Hydrographie, 1914, p. 7.—A. H. Clark, Die Crinoiden der Antarktis, 1915, pp. 125, 152, 182.—A. H. Clark, Amer. Journ. Sci. and Arts, **40,** 1915, p. 61. A. H. Clark, Smiths. Miscell. Coll., **65,** 1915, No. 10, p. 11.—A. H. Clark, Amer. Naturalist **49,** 1915, pp. 525, 526, 527, 542.

Diagnosis.—A genus of Bourgueticrinidae in which the arms divide once, on the second post-radial ossicle (being ten or twelve in number); all the post-radial ossicles are united in pairs by nonmuscular articulation; and the basals are separate, or are fused into a solid ring which is truncated conical, always longer than broad.

Geographical Range.—Caribbean Sea to the Azores and Morocco, and northwestward to southwest of Iceland; the Bay of Bengal; the vicinity of Banda and Celébes.

Bathymetrical Range.—From 1236 to 4255 meters (687 to 2419 fathoms).

Thermal Range.—The only two records, both in the Atlantic, are 3°.0C. and 40°.0 Fahr.

Included Species.—*Monachocrinus caribbeus* (A. H. Clark), *Monachocrinus minimus* (Döderlein), *Monachocrinus paradoxus* (A. H. Clark), *Monachocrinus perrieri* (Kœhler and Vaney), *Monachocrinus poculum* (Döderlein), *Monachocrinus recuperatus* (Perrier), and *Monachocrinus sexradiatus*, sp. nov.

Genotype.—*Monachocrinus sexradiatus*, sp. nov.

Monachocrinus sexradiatus, sp. nov.

Description.—The basals are anchylosed into a solid funnel-shaped ring which is rather more than twice as long as broad basally. In lateral view the sides of this funnel are almost parallel in the proximal half, but in the distal half they gradually diverge so that their final direction in relation to each other is the same as that of the two sides of the radial circlet, with which they merge without any deflection.

The radial funnel is composed of six similar radials of equal size, and is about twice as high as broad at the base; in profile it is seen to

be very slightly, almost imperceptibly, concave in the proximal half, becoming slightly convex in the distal; though the proximal end of the radial funnel is circular in outline, each radial distally gradually becomes convex dorsally so that in a dorsal view the distal end appears in outline as a hexagon, with rounded angles; the distance from the summit of the column to the distal edge of the radial circlet is 2 mm.

The IBr_1 are very long, about twice as long as the proximal width, with straight, slightly and regularly diverging sides.

The IBr_2 (axillaries) are little more than half as long as the IBr_1, considerably broader than long, with a blunt distal angle.

Both the ossicles of the IBr series have a low obscure broadly rounded median convexity, carrying forward the convexity of the distal portion of the radials, and sharp straight sides; the IBr_2 has a shallow pit just within the blunt distal angle.

The twelve arms are slender and narrow, with a smooth dorsal profile, the distal borders of the brachials not being produced, and measure 28 mm. in length from the distal edge of the radials; the brachials are all united in pairs by non-muscular articulations; the first brachial is slightly trapezoidal, longer outwardly than inwardly, broader basally than distally, half again as long as broad distally; the second brachial is not much more than half as large.

The first pinnule occurs on from the tenth to the fourteenth brachial, usually on the tenth.

The portion of the column attached to the crown is 22 mm. in length and consists of forty-three segments, of which the first fifteen are short and discoidal and the six following broader than long; the last five or six segments of the column as preserved are about four times as long as broad with very slightly, almost imperceptibly, enlarged ends, and a similarly almost imperceptible median raised girdle.

Another specimen, with the arms 25 mm. long, differs in having the five basals, which are of unequal size, separated from each other by sutures.

Locality.—Southwest of Iceland (61° 44′ N. lat., 30° 29′ W. long.).

Depth.—1135 fathoms.

Bottom temperature.—3°.0C.

Rhizocrinus M. Sars.

Rhizocrinus M. Sars, Forhandl. Vidensk. Selsk., 1864, p. 127 (genotype *Rh. lofotensis*, sp. nov.).

Geographical Range.—North Atlantic only; from northern Florida to Iceland, Ireland, and Norway, reaching to about 68°.5 N. lat. on the Scandinavian coast.

Bathymetrical Range.—From 140 to 2340 meters (77 to 1300 fathoms).

Thermal Range.—From 0°.1C. to 8°.4C. and 48°.7 Fahr.

Included Species.—*Rhizocrinus lofotensis* M. Sars, and *Rhizocrinus verrilli* A. H. Clark.

Bythocrinus Döderlein.

Bythocrinus DÖDERLEIN, Wiss. Ergeb. der deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898–1899, **17,** 1912, Heft 1, p. 11 (genotype *Rhizocrinus* [*Bythocrinus*] *chuni* or *Rh.* [*B.*] *braueri*, spp. nov.).

Geographical Range.—East Indies, and eastward to the northeastern coast of Africa; Atlantic coasts of northwestern Africa and southwestern Europe; Gulf of Mexico, and southward at least to Ceará, Brazil.

Bathymetrical Range.—From 158 to 1668 meters (88 to 927 fathoms).

Thermal Range.—The records are 3°.8 and 4°.6C., and 40°.5 Fahr.

Included Species.—*Bythocrinus braueri* Döderlein, *Bythocrinus brevis* (A. H. Clark), *Bythocrinus chuni* Döderlein, *Bythocrinus conifer* (A. H. Clark), *Bythocrinus intermedius* A. H. Clark, *Bythocrinus nodipes* (Döderlein), and *Bythocrinus robustus* (A. H. Clark).

Democrinus Perrier.

Democrinus PERRIER, Comptes rendus, **96,** 1883, No. 7, p. 450 (genotype *D. parfaiti*, sp. nov.).

Geological Range.—First found in a breccia containing a human skeleton at Guadeloupe, French West Indies; otherwise only known from the recent seas.

Geographical Range.—From Sulu (Joló) to Ceram Laut and Timor; near Krakatoa; coast of Morocco; Caribbean Sea and Gulf of Mexico.

Bathymetrical Range.—From 112 to 2050 meters (62 to 1139 fathoms).

Thermal Range.—No records.

Included Species.—*Democrinus parfaiti* Perrier, *Democrinus rawsonii* (Pourtalès), *Democrinus sabae* (A. H. Clark), and *Democrinus weberi* (Döderlein).

There are in the literature many records referring to species of this genus which are undeterminable.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

SPECTROSCOPY.—*Wave-lengths of the stronger lines in the helium spectrum.* PAUL W. MERRILL. Bureau of Standards Scientific Paper No. 302 (Bull. Bur. Stds., **14**: 159–166). 1917.

Wave-lengths of twenty-one of the stronger helium lines have been carefully measured photographically by means of the Fabry and Perot type of interferometer, using several separations. Nine of the lines were compared directly with the standard cadmium line 6438.4696A, the remaining lines being referred to these. The accuracy attained is nearly 0.001A, so that the lines are now available as convenient standards for many purposes. It is well known that the separation of the effective reflecting surfaces of the interferometer usually appears to be slightly different for different colors; the possibility of eliminating this effect is noted. The Kayser and Runge spectral series formula with constants derived from three consecutive lines will not reproduce accurately even the next member of any one of the six series.

P. W. M.

MINERALOGY.—*An American occurrence of miloschite.* EDGAR T. WHERRY and GLENN V. BROWN. American Mineralogist, **1**: 63–67. 1916.

The discovery of this mineral at Ely, Nevada, is announced, and a full description of its properties and composition given. It is shown to be a chromium-bearing kaolinite, and is considered a mineral species.

E. T. W.

PALEOBOTANY.—*Two new fossil plants from the Triassic of Pennsylvania.* EDGAR T. WHERRY. Proc. U. S. Nat. Mus., **51**: 327–329. 1916.

Descriptions of a new conifer, *Palissya longifolia*, and of a plant of unknown relationships, named *Brunswickia dubia*, from the Brunswick formation, in which it occurs.

E. T. W.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 571st regular meeting of the Biological Society of Washington was held at the Cosmos Club, May 5, 1917; called to order by President HAY; 25 persons in attendance.

On recommendation of the Council, DONALD R. DICKEY, Pasadena, California, and J. EUGENE LAW, Hollywood, California, were elected to membership.

Under the heading Brief Notes President HAY exhibited a lantern slide of some very immature flying squirrels.

The regular program consisted of two communications:

F. V. COVILLE: *The influence of cold in stimulating the growth of plants.* Mr. Coville stated that the spring and summer growing period of plants in regions having cold winters is followed by a period of dormancy which persists if the plants are artificially maintained at a relatively high temperature. A period of exposure to cold is needed to activate the plants for another period of growth. The mechanism of activation appears to be the liberation of enzymes acting on the stored starches, converting them to sugars; it is perhaps a change in the permeability of the cell membrane. It is normally brought about by cold, but mechanical injury or a period of drying may bring about the necessary changes. The operation is not controlled by the roots but acts independently in any exposed parts of the plants, so that if of two branches of a plant one is kept continually warmed and the other subjected to the usual winter chilling the former will not develop on the advent of summer temperatures, while the latter develops normally. Mr. Coville's paper was illustrated by numerous lantern slides. His communication was discussed by Messrs. E. A. GOLDMAN, WM. PALMER, L. O. HOWARD, W. P. HAY, and A. A. DOOLITTLE.

W. P. HAY: *The rate of growth in certain lower vertebrates.* Professor Hay gave some of his personal observations of the rate of growth of the loggerhead turtle, and observations, based on the published records of others, on the rate of growth of certain snakes and of an alligator. His communication was illustrated by charts and diagrams.

M. W. LYON, JR., *Recording Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 512th meeting of the society was a special meeting held on May 1 in the Natural History building of the National Museum to hear the address of the retiring president, Dr. JOHN R. SWANTON, whose subject was *Some Anthropological Misconceptions.*

Dr. Swanton began by calling attention to the cyclic nature of cultural movements and stated that like other beliefs the doctrine of evolution which so dominates the thought of our time is subject to the same law, and bound to have its rise, decline, and disappearance as an object of peculiar interest, and further, that the truth embodied in it will in time become so axiomatic that no particular attention will be paid to it and the chaff will disappear.

Unfortunately when pioneer anthropologists began to apply evolutionary ideas to their science, then in its infancy, they fell into a serious error. They assumed, with some justice indeed, that the existing peoples of the world presented features, some more and some less primitive, features which might be arranged into series showing the stages which mankind as a whole had passed through. But in selecting the "most primitive" features they worked on the false assumption that that which was most foreign to the ideas of the society in which they lived, in the cultural center of western Europe, as the most primitive. This resulted in a vast crop of pseudo-scientific evolutionary theories, each based on its author's own peculiar understanding of what was more and what less primitive. An assistant source of error was an over earnest attempt to find survivals analogous to the "vestigial characters" of biology in all kinds of cultural features, many of which were not vestigial at all. The speaker referred to several evolutionary theories of this kind, treating at some length those regarding the evolution of totemism from a matrilineal clan system, the evolution of marriage from a primitive promiscuity, and several theories concerning the origin of religion, such as those of Spencer, Tylor, Frazer, and Lang.

Secondly, the author took exception to the extreme uniformitarian attitude taken by certain anthropologists. He called attention to the fact that absolute uniformitarianism is impossible since even the inorganic world is based on discrete molecules, atoms, electrons, etc., while the organic world is based on independent organisms. In the same way when we turn to the culture history of mankind we find that ideas, although progressive, do not roll into consciousness with the even motion of a wheel, but come at certain definite times and places.

Along with this extreme uniformitarianism he believed too much stress had been placed on the unconscious or subconscious side of evolution in human institutions. Important as the latter undoubtedly is and much as it is neglected by the man of average intelligence, it acts less toward the development of new institutions than toward the preservation of institutions already in existence, and is accompanied by degeneration, or at most imitation, rather than by absolute origination.

In this connection Dr. SWANTON took occasion to criticise a certain type of student who, because he observes the powerful effect of subconscious imitation, assumes that there is an extra-mental current which settles all problems, and looks cynically upon conscious efforts to bring about change. When examined closely this seemingly unconscious current would be found to be a resultant of forces, each of which was the decision of some individual or some group of individuals at a definite time and place. He believed that if any of these decisions had been different the stream itself, the course of history, would in some measure have been different.

In the discussion which followed the address Dr. LEO J. FRACHTENBERG agreed in main with the assertions made by the speaker. He called attention to the fact that the error of particularization is well exemplified in Westermarck's "Origin of Primitive Ethics." Dr. Frachtenberg expressed the belief that the principles of unconscious evolution should not be underestimated. Dr. TRUMAN MICHELSON added as another misconception the supposition that the languages of primitive peoples indicate a low mentality, stating that it is possible to express complicated ideas by means of these languages but that the ordinary life of the people does not require such expression. Another misconception, according to Dr. Michelson, is the arranging of languages in a scale of superiority with inflectional languages as the highest point of development.

In closing the discussion Dr. Swanton stated that although it is true that the unconscious element plays a very important part in the evolution of culture, its functions are conservative or, at most, imitative, with a tendency toward degeneration, whereas the conscious element is that which creates, that which produces positive advances.

FRANCES DENSMORE, *Secretary*.

CONTENTS

Original Papers

Page

Mineralogy.—Aurichalcite from Big Cottonwood Canyon, Salt Lake County, Utah. A. Ledoux 361

Mineralogy.—The indices of refraction of analyzed rhodochrosite and siderite. Edgar T. Wherry and Esper S. Larsen 365

Genetics.—The rôle of selection in evolution. W. E. Castle 369

Zoology.—A revision of the recent genera of the crinoid family Bourgueticrinidae, with the description of a new genus. Austin H. Clark 388

Abstracts

Spectroscopy 393

Mineralogy 393

Paleobotany 393

Proceedings

The Biological Society of Washington 394

The Anthropological Society of Washington 395

Vol. VII

No. 13

July 19, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII JULY 19, 1917 No. 13

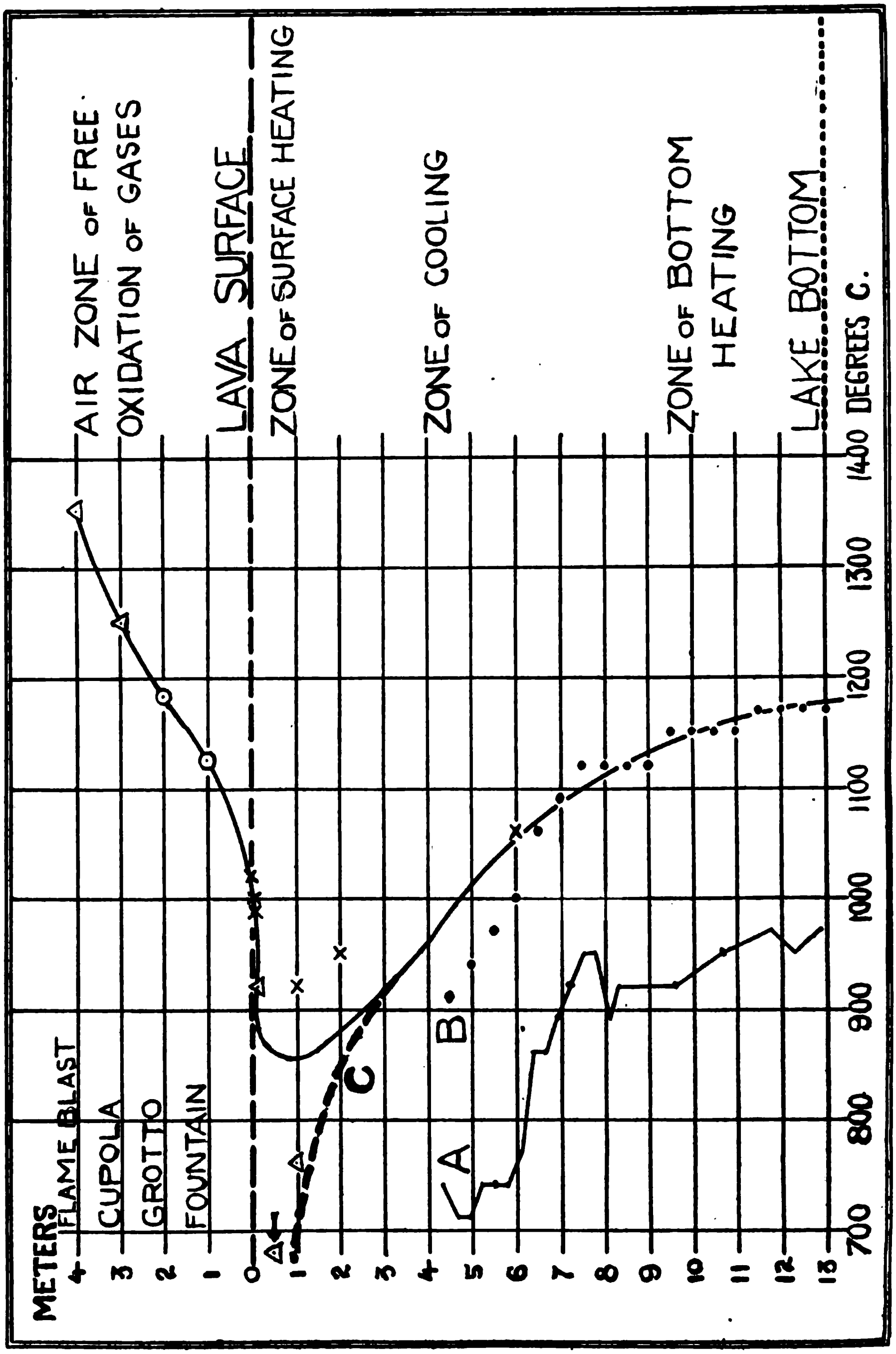
GEOPHYSICS.—*Thermal gradient of Kilauea Lava Lake.* T. A. Jaggar, Jr., Hawaiian Volcano Observatory.

Experimental temperature measurement with Seger cones in steel pipes thrust into the lava and flaming cones in 1917, when the lava pool of Halemaumau became accessible, yielded results of increasing accuracy as the method was improved and the sources of error or failure were discovered and eliminated.

The temperature of the fountains and grottoes, where gas effervescence induces ebullient doming, flaming, and spraying of incandescent melt, is now well known.[1] Excessive oxidation of the combustible constituents S, CO, and H on contact with air makes the confined and continuously flaring grottoes hotter than the central fountains. The temperatures vary, but 1130°C. for the fountains and 1180° for the open grottoes (fig. 1, circles) are recorded measurements approaching the maximum. Measurements in the past have been made with Féry[2] and Holborn-Kurlbaum optical pyrometers and with the platinum-rhodium element, and have shown that the surface temperatures of the Kilauea magma range from 940° to 1185°. Temperature measurement below the surface, or in the gas-filled chambers and orifices of flaming blowing-cones on the benches, has not been attempted before this year.

[1] Report Hawn. Volcano Observatory, Boston, January–March, 1912, p. 51. Bul. Geol. Soc. Amer., **24**: 601. 1913. Am. Journ. Sci., **36**: 151. 1913.

[2] Proc. Am. Acad. Arts and Sci., **47**: No. 3. 1911.


METERS
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FLAME BLAST
CUPOLA
GROTTO
FOUNTAIN
AIR ZONE OF FREE OXIDATION OF GASES
LAVA SURFACE
ZONE OF SURFACE HEATING
ZONE OF COOLING
ZONE OF BOTTOM HEATING
LAKE BOTTOM
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B
C
700
800
900
1000
1100
1200
1300
1400
DEGREES C.

Fig. 1

The writer determined by sounding on January 23, 1917, that the liquid lava in the lake was 14 meters deep, and that it rested on a seemingly pasty resistant bottom. This bottom was partially uncovered and revealed by subsidence of the liquid part of the lava column in February, 1917, confirming the soundings. Soundings of the remnant liquid pool on March 24 showed that the depth had diminished to 9 meters. After rising had been resumed, on May 2, the depth at the same locality was 13 meters. The liquid of the lake magma rises through conduit wells in the bench magma and circulates by convection through the conduits and sinkholes, the semi-solid bench magma forming the lake bottom and margins.

The thermal gradient of the liquid lake to its bottom is not the gradient of the lava column. That could only be determined by profound soundings along with temperature measurements in the conduits and sinkholes. The liquid lake is a shallow pool of lava continually engulfing vesicular crusts, which must be full of air, and which do not melt at once, as the upper temperatures are not those of superfusion. The determination of the gradient of the pool is of interest to show (1) whether reaction between gases rising from the bottom produces increased heat upward, or (2) whether surface radiation and expansion of the gases in vesicles make a graded cooling effect upward, or (3) whether a combination of these two processes, and also surface oxidation of the gases, bottom oxidation due to foundered crusts containing air, or bottom radiation, in some way complicate the curve. That it is a smooth curve seems unquestionable. Condition (3) seems nearest the measured gradient.

The measurements of 1917 are divided into three groups: group 1 (indicated by triangles in the accompanying diagram), January-March reconnaissance of method and surface temperatures; group 2 (indicated by crosses) in which the upper gradient was accurately determined in April with small steel pipes as containers of Seger cones; and group 3 (dots, *A* and *B*), lower gradient determined May 2 with special apparatus, the corrected error being due to air cushion in large pipe. It was found in the earlier experiments that pipes from 3 to 8 cm. in-

ternal diameter, containing Seger cones with their tips held free in air, failed to transmit the full temperature of the melt to the cones, owing probably to circulation of the air and consequent heat insulation for the limited time of exposure (five to eleven minutes). In later tests with 12-mm. pipes the results were accordant with tests in glowing caverns where the Seger cones are exposed directly, and with the observed incandescence. Accordingly where a large pipe is used to contain a removable series of batteries of cones exposed all at once, the relative temperatures are measured, but the figures are too low by an error approximately constant. *A* and *B* of the diagram show respec-

TABLE 1

GROUP 1. UPPER TEMPERATURE (TRIANGLES)

DATE	LOCATION	EXPOSURE	TEMPERATURE (SEGER CONE EFFECT)	CONDITIONS
1917		*min.*		
January 11	1 meter below surface of lake	6	Fusibility 990° unaffected	Special steel container for 6 Seger cones in steel cylinder 7.6 cm. internal diameter attached to steel pipe 2.5 cm. internal diameter. Pipe bent sharply at lava surface, straight above *and below*
January 15	1 meter below surface	11	Fusibility 770° unaffected	Cylinder 7.6 cm. Compare April 5
January 18	20 cm. below surface	1	Fusibility 870° slightly affected	Steel pipe 2.5 cm. internal diameter, heated first in air 30 cm. above lake 30 minutes. Seger cones in spiral of spring steel in sealed end of pipe. Trouble with moving crusts
January 18	50 cm. below surface	3	Fusibility 590° unaffected	2.5-cm. pipe, heated first in air 27 minutes, much crust trouble
January 18	10 cm. below surface	3	Fusibility 1070° unaffected	2.5-cm. pipe, heated first in air 27 minutes, much crust trouble
January 22	1.5 meters below surface	5	1070° fused	2.5-cm. pipe, heated first in air over fountaining grotto 10 minutes, then submerged in boiling grotto-lava

TABLE 1—Continued

DATE	LOCATION	EX-POSURE	TEMPERATURE (SEGER CONE EFFECT)	CONDITIONS
1917		*min.*		
January 26	3.6 meters above lava in blowing cone	9	1130° fused 1250° estimated interior cone 1350° estimated flame	2.5-cm. pipe, inserted in orifice 25 cm. diameter for a length of 70 cm. Blast flame emerging from orifice, pipe bathed in burning gas within. Pipe fuses and oxidizes to dripping incandescent product, eaten through for length of 23 cm. at flaming window. Color of pipe bright orange inside cone, yellow opposite flame. Temperatures estimated from relative glows and effects on steels. (Pipe, cap, spring steel container for Seger cones)
March 28	8 cm. within crevice 5 cm. across. Bench magma	5	920° fused	Calibration test in glowing orifice of cone, cherry-red chamber. Seger cones inserted successively one at a time on open wire. Basis for weighting other tests according to glow

tively the actual and the corrected readings of the lower gradient obtained in this manner, with the correction checked by measurements of group 2, in which small pipes were used inserted to a depth of 6 meters.

The upper lake gradient (crosses) of April 5–6 shows three points on a nearly straight line for 1, 2, and 6 meters of depth with 30°C. increment of temperature per meter downward. The average increment per meter of the lower, May 2, gradient (dots) is the same, a line joining the 5-meter point and the 13-meter point lying parallel to the April 5–6 line. The divergence of the two above the 6-meter point may be due to instrumental errors or may be due to a difference in convectional circulation on the two days. On April 5–6 the southeast pool where the experiments were made was streaming rapidly eastward on the

surface and making only thin skins; on May 2 this pool was partially separated from the larger lake and tended to form thick stagnant crusts. This surface was therefore much cooler on May 2, in accordance with the tendency of the *B* curve. A

TABLE 2

GROUP 2. UPPER LAKE GRADIENT (CROSSES)

DATE	LOCATION	EXPOSURE	TEMPERATURE (SEGER CONE EFFECT)	CONDITIONS
1917		*min.*		
March 30	15 to 20 cm. below surface	5	1020° fused	12-mm. pipe in streaming liquid lava of "bright lines" at margin of torn crust. Cones loose in sealed end of pipe. Accurate
April 5	1 meter below surface	5	920° fused	12-mm. pipe, thin crust, good conditions. Battery of Seger cones in iron wire gauze in sealed end of pipe. Accurate
April 5	6 meters below surface	5	1050° fused	12-mm. pipe, thin crust, good conditions. Gauze container. Accurate
April 6	2 meters below surface	5	950° fused	12-mm. pipe, gauze container, through thin crust, 1 meter from bright line of moving channel lava. Accurate
April 6	8 to 13 cm. below surface	5	990° unfused	12-mm. pipe, gauze container, through crust adjacent to bright line of moving lava. Lava tended to solidify around pipe
April 6	10 cm. below surface	4	990° fused	12-mm. pipe, gauze container, under crust 2 to 3 cm. thick, hence actual immersion in liquid 7 to 8 cm., next to bright line of moving lava, different locality from previous test same day

solid-line curve has been drawn in the diagram intermediate between the two, and this line is not far from a correct expression of the temperature of the Kilauea pool at its eastern margins,

on the side of the sinkholes, and relatively remote from the conduit wells. The conduit gradient, to the writer's thinking, should be different.

As indicated in the figure, four heat zones are present, from the hottest flame blast of burning gas in a high "blowing-cone" on the border benches, downward to the lava lake bottom.

The upper atmospheric zone shows a steep gradient of increasing temperature from 1000°C. at the "bright lines" of

TABLE 3

GROUP 3. LOWER LAKE GRADIENT (DOTS)

DATE	LOCATION	EXPOSURE	TEMPERATURE (SEGER CONE EFFECT)	CONDITIONS
1917		*min.*		
May 2	4.38 meters to 12.93 meters below surface	8	20 temperatures in series; 740° above to 970° below fused (*A* in figure 1, corrected in *B*)	Steel pipe 3.8 cm. internal diameter, 22.70 meters long, 20 gauze containers on wire in pipe all exposed at once. Immersed at angle 35°, vertical depths shown in *A*. 29 Seger fragments in each container, fusibilities 590° to 1290°. Corrected for probable constant error due to air insulation of large pipe and averaged for each half-meter, as smooth curve, at *B* (dots). Correction based on April 5–6 curve (crosses). Immersion to lake bottom, heavy crust on surface

the lava surface through the fountains, the confined grottoes on the lake shore, and still more confined cupolas of driblet cones, to the puffing vents where banners of flame play above these cones as natural blow-pipes of burning sulphur and hydrogen. These vents will fuse steel and hence reach a temperature of at least 1350°.

The zone of surface heating is a somewhat paradoxical region at the lava surface where hot fountaining and hot "bright lines"

compete with enormously rapid radiation and crusting, which latter ordinarily is greatly dominant. The fall in temperature upward through a surface crust 8 cm. thick is fully 400°; the rise in temperature from the region a half-meter below the crust to the "bright lines" amounts to from 100° to 150°, and to the fountains 250°. Heavy crust may form in thirty minutes and is a porous insulator from the heat of the melt beneath such that a man could stand on it for an instant without suffering. Thin crusts form instantly and continuously, the "bright lines" being wavy bands on the lava surface at the margin of the rending crust, the upwelling melt and gas eroding the air-filled vesicles of the crust. Thus heat-generation ensues, through completion of the reaction between rising unstable gas mixtures and through union with atmospheric oxygen. Foundering of crusts liberates much heat, carries down air, and induces fountaining.

It will be seen that the hypothetical gradient of cooling effect carried to the heavy crusts, disregarding the reheating due to surface reactions, would exhibit no bend upward to the right as in the diagram at depth 1 meter, but rather a curve to the left ending on the surface at about 400° (*C* in diagram). A completely crusted pool therefore, with gas reactions satisfied elsewhere, might reveal very low temperatures just beneath the surface in accordance with curve C. This may account for some of the anomalous records of group 1 (triangles), and others not here recorded which the writer has obtained with a thermocouple. It is hoped to explore this surface region more completely.

The zone of cooling from depth 7.5 meters to the surface crusts registered an average loss of temperature upward on May 2 of 70° per meter for the lower 3 meters. This middle region would appear to suffer a marked bend in the gradient from a relatively heated zone beneath. The viscosity should thus increase rapidly from depth 7.5 meters to depth 1 meter, a condition favorable for confinement of large gas bubbles beneath the zone of surface heating. The cooling is in the main due to surface radiation, aided doubtless by gas expansion. The surface heating appears to be localized and sudden, occurring as a result

of the accumulation of gas under an impervious crust, the release being continuous at times of rapid circulation and spasmodic during stagnant times.

The zone of bottom heat reaches a maximum not greater than that of the fountaining grottoes, and the gradient must recurve to lower temperatures in the stiff bench magma below. Continued measurement will show whether the relatively even temperature (1120°–1170°) of the lower 5 meters of the lake is that of the rising conduit lava. The writer surmises that it is hotter than the conduit lava, because the latter generally crusts over extensively and shows low incandescence. Geologic evidence from raised portions of the under-lake marginal slopes indicates that foundered crusts pile up beneath the lake, and experiment shows that they would glaze over and confine air. On reaching the bottom of the lava pool such accumulations, by gradually releasing air to react with the volcanic gas, would produce reheating. They would continuously soften and disintegrate, but during the prolonged reaction, always supplied by new foundering, the bottom would present what the measurement appears to reveal, a combination of viscosity and high temperature. The gaseous products of the reaction would accumulate in the zone of cooling and would be released explosively as central or border fountains where the accumulation became excessive. As yet it has not been possible to force a pipe down into the stiffer and lower bottom material which might show declining temperature. At the best, exploration of the deep region is difficult and somewhat dangerous, and such experiments as the immersion of May 2 must be carefully prepared, with expectation of many reverses.

CRYSTALLOGRAPHY.—*The thermodynamic reversibility of the equilibrium relations between a strained solid and its liquid.*
F. E. Wright and J. C. Hostetter, Geophysical Laboratory.

In the thermodynamical treatment of the effect of pressure on the melting temperature or on the solubility of a crystal it has been customary tacitly to assume that the process is reversible, because only under such conditions do the equilibria rela-

tions represented by the thermodynamic equations obtain. In case both the solid and the liquid are under the same pressure (hydrostatic compression) there is no difficulty in conceiving of a thermodynamic cycle which is reversible and from which the ordinary Clapeyron equations for uniform pressure can be derived. But in the case of a crystal under load the crystal phase is under a state of pressure different from that of the liquid; the pressure throughout the system is no longer uniform; in the passage of the material from one state to the other a pressure factor enters and tends to render uncertain the reversibility of the process. Nevertheless, its reversibility has been assumed either directly as self-evident, or indirectly by postulating conditions (semipermeable membranes, etc.) which are experimentally not attainable; but no direct evidence of the reversibility of the process has heretofore been offered, so far as the writers can ascertain, in support of this fundamental assumption.

The relations between a strained solid and its liquid have been discussed at various times by different authors under the headings of "non-uniform," "one-sided," "differential," or "unequal" pressure. Each of these titles is suggestive of the fact that in these discussions pressure was assumed to be unequal on the various parts of the system being investigated. The equations between the various factors involved in the treatment of such a system have all been developed from the theoretical side, and none of them has ever been subjected to a thorough experimental demonstration. This lack of experimental evidence on the subject probably accounts for the diversity of effects postulated for a given pressure acting non-uniformly;—the effects so postulated vary a thousand-fold and should have been submitted to experimental test long ago.[1]

Perhaps the first investigator to study the effects of non-uniform pressure was James Thomson[2] who in 1862 made a careful distinction between stresses applied only to the solid phase of

[1] It may be mentioned here that preliminary results on the influence of non-uniform pressure on solubility indicate that the effect so produced is very small. Hostetter, J. C. J. Wash. Acad. Sci., **7**: 79. 1917.

[2] Thomson, J. Phil. Mag., (4) **24**: 395. 1862; Proc. Roy. Soc., **11**: 473.

a system, and those stresses applied equally to both a solid and its liquid. That he regarded the process as completely reversible is clearly shown in the following quotation from his work:

> . . . . The following line of reasoning to show that stresses applied to a crystal will cause a resistance to the deposition of additions to it from the liquid, or, in other words, a resistance to its growth, will, I think, prove to be correct. When a crystal grows, the additions, it seems to me, must lay themselves down in a state of molecular fitting, or regular interlocking with the parts on which they apply themselves; or, in other words, they must lay themselves down so as to form one continuous crystalline structure with the parts already crystallized. It thus seems to me that, if a crystal grows when under a stress, the new crystalline matter must deposit itself in the same state of stress as the part is on which it lays itself. If, then, we consider a spiculum of ice growing in water, and if we apply any stress, a pull for instance, to it while it is thin, and then fix it in its distended state, and if then by the transference to the water beside it of cold taken from any other ice at the freezing point we cause it to grow, which it may do if there be no other crystal of ice beside it more free than it to receive accessions, then the additional matter will, I think, lay itself down in the same state of tensile stress as the original spiculum was put into by the applied pull. The contractile force of the crystal will thus be increased in proportion to the increase of its cross sectional area. If it now be allowed to contract and relax itself, it will give out, in doing so, more mechanical work than was applied to the original spiculum during distention. Hence there would be a gain of mechanical work without any corresponding expenditure; or, we could theoretically have a means of perpetually obtaining mechanical work out of nothing, unless it were the case that greater cold is required to freeze water into ice on the stressed crystal than on a crystal free from stress. Hence we must suppose that a greater degree of cold will be required to cause the stressed crystal to grow. . . . .

In 1878 Gibbs developed in detail the relations defining the conditions of equilibrium for solids in contact with fluids, having regard to all possible states of strain of the solids.[3] He introduced no direct evidence as to the reversibility of the process under consideration but from certain of his statements we may infer that he considered the process reversible. He made a distinction between the effects on equilibrium caused by strain in "isotropic" and "crystallized" bodies; this is stated specifically

[3] GIBBS, J. WILLARD. The Scientific Papers of, p. 184.

in his discussion of "surfaces of discontinuity between solids and fluids.[4]

While some of the more recent writers on the subject have not discussed the reversibility of the fundamental process, it is interesting to note that the reversibility of the process has indeed been questioned by Tammann[5] and by Pockels.[6] Nernst,[7] on the other hand, defended the reversibility of the process and considered that the thermodynamic treatment of such cases may be carried out exactly.

Johnston and Adams[8] in their treatment of the effects produced by non-uniform pressure on melting took the position that, inasmuch as the main process may be considered to be made up of an aggregate of reversible local meltings, the process itself may be considered reversible. Niggli,[9] following a line of reasoning similar to that used by Gibbs, held to the view that, although the actual process is not reversible, a comparison of thermodynamic potentials at the boundary solid-liquid for different states of strain in the solid is permissible. Still another method of avoiding the issue as to the reversibility of the process is that employed by Hassellblatt,[10] namely to consider the process an "indirect equilibrium."

EXPERIMENTAL.

In the present paper both experimental and geologic field evidence are given which prove the correctness of the assumption that the process, even for nonuniform pressure, is reversible and that on crystallization the liquid enters into the crystal state under the same state of strain as that of the crystal on which it is deposited. This statement is proved by three distinct lines of evidence and is supported by many other facts which have a

[4] Loc. cit., p. 316.
[5] Tammann, G. Ann. Phys., (4) **7**: 198. 1902.
[6] Pockels, F. Neues Jahrb. f. Min., Centralblatt 1906, p. 667.
[7] Nernst, W. Theoretical Chemistry, 4th ed., p. 667.
[8] Johnston, J. and Adams, L. H. Am. Journ. Sci., **35**: 212. 1913.
[9] Niggli, P. Zeit. f. anorg. Chem., **91**: 125. 1915.
[10] Hasselblatt, M. Zeit. f. anorg. Chem., **93**: 75. 1915.

less direct bearing on the problem. The direct lines of evidence are:

1. Observations in plane polarized light of the relative states of strain of an isotropic crystal, growing under load in a supersaturated solution, and the layers deposited on it.

2. Examination under the petrographic microscope of the relative states of strain, after removal of the load, of a crystal and the layers which were deposited on it while it was under load.

3. Examination under the petrographic microscope of the state of strain of certain minerals in rocks—such as schists, gneisses, quartzites—which geologic field evidence proves were in part crystallized under load.

Less direct proof is afforded by experimental evidence on the relative rate of growth and the increased solubility of crystals under load; and also by the directive influence of lines of thrust on the direction of maximal rate of crystallization, as proved both by geologic field evidence and by experiment. These will be considered in the order named.

1. *The relative state of strain between a loaded crystal and layers freshly deposited upon it from its supersaturated solution.* To the crystallographer the process of crystallization of a substance consists essentially in the regular orientation, as a result of certain directive interatomic forces, of all molecules of the liquid which come within the range of influence of these forces. The crystal itself consists of regularly oriented series of the component atoms arranged in interpenetrating space lattices. As a result of the mutual interaction of these atoms or groups of atoms around points regularly arranged in space, the properties of the crystal are different in different directions; certain symmetry relations hold and find expression not only in the crystal form but also in the behavior of the crystal toward external forces such as mechanical forces (pressure, tension), chemical forces (rate of solution, crystal habit, etch figures), vibratory movements set up in the ether (X-rays, light, heat, and electric waves), magnetic forces, etc. The law of force between the atoms has not yet been established; it is known, however, that at relatively short distances (measured in millimicrons) the interatomic attraction

is slight, but increases rapidly as the distance decreases down to a certain limit. Beyond this limit forces of repulsion are set up and, as a result, the atoms are normally separated definite distances which can be accurately measured by X-ray analysis.

In case a crystal is placed under load the atoms are squeezed together, a state of strain exists within the crystal, and stress forces are set up which oppose the load and keep the crystal in equilibrium. The essential feature to note is that in this case there has been added to the force-function, valid at a particular point, a new term resulting from the stresses set up on loading the crystal. The loaded crystal is thermodynamically a different thing from the unloaded crystal; crystallographically the loaded crystal on growing orients the atoms or groups of atoms which come within the range of influence of its component atoms according to the force function which then obtains for the equilibrium and this is of course the unstressed crystal force function modified by the stresses set up on the application of the load. This conception holds whether the distribution of the strain be uniform or nonuniform within the crystal, but since with each different state of strain the energy relations in the crystal change, there can be real equilibrium only when the energy relations over any given area of the crystal in contact with the solution are the same as those over any other similar area. This postulates, in general, practical uniformity of distribution of load throughout the crystal. Incidentally it may be remarked that the energy contributed by the load to the crystal compared with the latent heat of the crystal is of a very small order of magnitude and that therefore we may conclude *a priori* that the effect of uniform or nonuniform pressure on the melting temperature or on the solubility of a crystal cannot be great.

If the above crystallographic conception of the problem be correct, a crystal growing under load should exhibit appreciably the same state of strain in a layer freshly deposited on the original crystal as exists in the part of the crystal which adjoins the new layer. Differences in strain between different parts of the original crystal, as a result of unequal distribution of load, should also be manifested in the freshly deposited layers. In other words

the atoms and group of atoms on deposition enter into the crystal state in practically the same condition of strain as that of the orienting crystal particles to which they become affixed. In view of the increased size of the crystal there is of course a general decrease in strain throughout the crystal but this affects the entire crystal (both new and old parts) and is so slight that it is not appreciable in the phenomena presented by the crystal when examined in polarized light. The newly deposited layers are not deposited in a state corresponding to that of the unloaded crystal (isotropic state) and there is no line of demarcation in strain between the original crystal and the freshly deposited layers.

Experiments. The method of observation employed in these experiments is essentially that first used by Brewster[11] in measurements of the relative strain in glass. Brewster discovered that a plate of glass under load is birefracting and that the optical effect is sensibly proportional to the intensity of the strain (load). The problem was studied later by Fresnel,[12] F. E. Neumann,[13] Wertheim,[14] Macé de Lepinay,[15] Kerr,[16] Pockels,[17] and recently by F. Coker,[18] and F. E. Wright.[19] As a result of Brewster's law that the birefringence, or path difference, is proportional to the strain, the determination reduces to the simple determination of the path difference between the two waves transmitted through the stressed crystal in a direction normal to the direction of the applied load, the faster wave vibrating parallel to the direction in which the load is applied, the slower normal to this direction. If white light be used as source of light the path difference gives rise to interference colors which follow approximately the Newton color scale. For qualitative observations uniformity of interference tint over the field near the edge under observation is a criterion for uniformity of strain in

[11] Philosophical Transactions 1814, 1815, 1816.
[12] Oeuvres Completes.
[13] Pogg. Ann., **54**. 1841.
[14] Comptes Rendus, **32**, **33**, **34**. 1854.
[15] Ann. chim. phys., **19**: 1–90. 1880.
[16] Phil. Mag., (5) **36**: 321. 1886.
[17] Ann. d. phys., **7**: 745–771. 1902; **9**: 220–223. 1902.
[18] Phil. Mag., **20**: 749. 1910.
[19] J. Wash. Acad. Sci., **4**: 595–598. 1914.

the crystal, provided of course the thickness of the layer traversed by the light waves remains constant. The path difference can be measured by a compensator of the Babinet, the graduated quartz, or the biquartz[20] type.

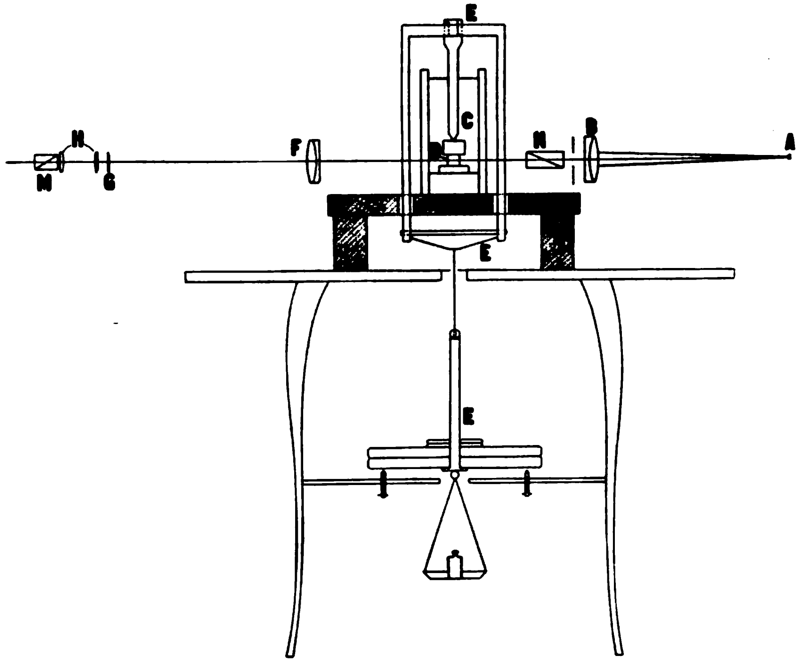

Fig. 1. Diagram showing arrangement used in the study of crystal growth under load. The crystal *D* is placed in its supersaturated solution in the tank *C* which has parallel plate glass sides. Load is applied to the crystal through a block on which the point of the loading apparatus *E* presses. Increased load is obtained by adding weights on the scale pan of *E*. A beam of parallel plane polarized light from the light source *A* is sent through the crystal into a low power microscope consisting of an objective *F*, a quartz compensator *G*, a positive eyepiece *H*, and an analyzing prism *M*.

The method actually adopted for the observation of the growing crystals is shown in Fig. 1 in which *A* is the source of light, *B* a condenser lens, *N* a polarizing prism, *C* a receptacle with plane parallel plate glass sides, *D* the loaded crystal, *E* the ap-

[20] Am. Journ. Sci., (4) **26**: 370–371. 1908; Carnegie Institution of Washington, Publication 158, 134–135. 1911.

paratus for applying the load, *F* a weakly magnifying objective lens, *G* a quartz compensator, *H* a positive eyepiece, and *M* the analyzing nicol.

Preliminary experiments were carried out on alum crystals, but for accurate measurements these crystals proved to be unsatisfactory because of the crystal habit, which is octahedral and does not allow the direct passage of the light through the crystal at the edges, since its interfacial angles are not 90°. This defect was remedied in part by grinding parallel surfaces on the crystal normal to an octahedral plane and protecting these surfaces by cover glass slips; this procedure, however, was satisfactory for quantitative measurements. The observations so far as carried proved that the octahedral layers deposited on the crystal under load are in the same state of strain as the original crystal. In order to obviate the effects of prismatic refraction the refractive index of the solution was made equal to that of the alum by the addition of glycerine, but out of this supersaturated solution crystals did not grow satisfactorily.

After unsuccessful experiments to grow large sharp unmodified cubes of sodium chloride, and also of potassium chloride, satisfactory crystals of sodium chlorate were obtained which were sharp cubes without truncations and well suited for the purpose. These crystals were not, however, entirely free from local strain but showed between crossed nicols faint interference colors of first order gray. The interference colors moreover do not change rapidly with change in load, and, to render the changes in path difference more evident, a sensitive tint plate was employed in qualitative observations.

Experiment 1. A crystal (2 by 3 by 4 mm.) was subjected to a load of about 20 kgm. per square centimeter. The load was not, however, uniformly applied, as was shown by the changes in interference colors from point to point; the unequal loading resulted chiefly from the bending of the metal disk (*D*, fig. 1) which was placed between the crystal and the rod (*C*, fig. 1); also in part from slight irregularities in the surface of the crystal. The interference colors ranged in general from first order gray to white, and were rendered more sensitive to slight changes in

path difference by the insertion of a sensitive tint plate. Under these conditions the parts of the crystal under tension appeared first order yellow, the neutral portions purple, and the parts under compression second order blue to blue green.

Deposition on each of the vertical crystal faces of the crystal under load took place at the rate of 0.12 mm. per hour, i.e., the crystal increased in thickness every half hour 0.12 mm. (0.06 mm. on a side). The interference colors in the newly deposited layers were identical with the colors in the original crystal and no line of demarcation was visible. At a point where the edge of the original crystal exhibited a neutral or sensitive violet color, there the layer in process of deposition on that point showed the same interference color, and so on for yellow and blue interference colors. The gradations from the zone of compression to that of tension in so far as they extended to the outer vertical surface under examination were conformable with the gradations in the original crystal. In short there could be no doubt that the material on deposition from the supersaturated solution entered into the crystal state in the state of strain of the crystal atoms to which it became affixed. So far as measurements could be made, the change in path difference for a load of 20 kg. per square centimeter is about 200 $\mu\mu$ per 1 cm. of material traversed. This value is not accurate but is only a rough approximation. On release of the load the crystal returned to its original condition.

After one hour's growth under these conditions the load was increased to 40 kg. per square centimeter; the path difference increased to about double the former value and the zones of compression and tension were more sharply marked, with a narrow zone of gradation between the two. As before, the freshly deposited layers entered into the crystal state in the condition of strain of the part of the crystal on which they were in contact. The load was increased to 60 kg. but this exceeded the crushing strength of the crystal, which broke into fine powder on yielding.

Other experiments with other crystals yielded similar results and need not be described in detail.

2. *Examination in polarized light of crystals which have grown under load.* In the case of a crystal which has grown under load, the original crystal on application of the load was put into a state of strain; on release of the load the crystal resumed its original state of no strain, or isotropism. In case the layers which were deposited on the strained crystal were laid down in any state of strain other than that of the original crystal, then on the release of the load a difference in the state of strain should exist between these layers and the original crystal, since the same load, or release of same, cannot arbitrarily produce different states of strain in the same material under the same conditions. On the other hand if examination shows that there is no difference in strain between the new and the old material after release of the load the conclusion is valid that the material was deposited in the state of strain of the original crystal at the time of deposition.

Examination under the petrographic microscope of crystals of alum and of sodium chlorate on which the outer layers had grown while the crystal was under load, showed no difference in state between the outer and the inner parts of the crystals. Most of the crystals were not uniformly isotropic but exhibited areas of compression and of tension (differences in interference color) and these areas passed indiscriminately and without break from the central part to the outer layers of the crystal, thus confirming the evidence gained by direct observation of crystals growing under load.

Geologic field evidence. To the student of rocks the presence, in metamorphic rocks which have been in part recrystallized, of layers of fresh crystal substance on original crystals which at the time of deposition were under heavy strain is a fact of common observation. Thus in quartzites and metamorphic sandstones the further growth, under load, of the original sand grains by the deposition of fresh material is clearly shown; similarly the growth of feldspars. On the other hand the growth of such metamorphic minerals as garnet, which are commonly isotropic when examined under the microscope but which at the time of formation were under conditions of heavy strain, proves that the

crystal state as modified by any external mechanical system of forces is the state into which freshly precipitated material enters when deposited on the crystal to which it becomes affixed.

Many more examples of a geologic kind of the growth of minerals under strain might be cited, but the above suffice to establish the fact that, whatever is the nature of the orienting polar crystal forces, when these are modified slightly by external forces, the resultant of the two systems dominates and orients groups of atoms in the act of crystallization, as they become affixed to the strained crystal, in such a way that they conform to the state of deformation of the original material.

Evidence of growth and solubility rates. In experiments on the rate of growth and the rate of solution of alum crystals which are not uniformly strained, it has been repeatedly observed that the points of greatest strain dissolve more rapidly than areas of the same crystal which are under less strain; also that on crystal growth the areas of less strain tend to grow more rapidly than areas of greater strain. This indicates that the state of strain of a crystal is a factor to be considered in problems of crystal growth. If the freshly deposited layers did not enter into the state of strain of the original crystal but in an isotropic state there should then be no difference in the rate of growth for differently strained parts of the crystal; similarly the fact that the rate of solubility is affected by mechanical strains proves that the strained crystal is in a state different from that of the unstressed crystal.

Evidence of effect of thrust on direction of crystal growth. That the direction of mechanical thrust has a direct influence on the direction and rate of growth of crystals is proved by geologic field evidence and also by laboratory experiments.[21] In the laboratory experiments cubes of wollastonite and other silicate glasses were held under load at a temperature at which crystallization took place slowly, but at which the glass was still relatively rigid and able to support a load without much flow. Longitudinal sections across the cubes crystallized under these conditions showed that the prismatic directions of the crystals

[21] Wright, F. E. *Schistosity by crystallization.* Am. Journ. Sci., (6) 190.

in the central portion of the cube were invariably normal to the direction of the applied load in the direction of least resistance, which is also the direction of flow. Further experiments along this line with polymorphic crystals of low inversion temperatures and of prismatic forms, are in progress. These prove that external directive pressure is a factor which enters into the crystal force system, and are in accord with the results cited above.

Summary. Experimental proof is offered in the foregoing pages of the reversibility of the relations between a strained solid and its liquid. The mechanism of this action has been found to be exactly that postulated in 1862 by James Thomson from a purely theoretical basis: namely, that, on crystallization, each particle (atoms and groups of atoms) enters into the crystal state in the condition of the crystal at the point to which it becomes affixed; and that if the crystal be under a state of strain the freshly deposited particle enters into the same state of strain. This fact is essential if equilibrium relations are to exist between a strained crystal and its liquid, because only under these conditions can the relations be strictly reversible, and thermodynamic reversibility is necessary if the thermodynamic equations are to be valid.

MINERALOGY.—*Ilsemannite, hydrous sulphate of molybdenum.*

WALDEMAR T. SCHALLER, Geological Survey.

A secondary blue molybdenum mineral was described in 1871 and named ilsemannite; according to Dana,[1] it is cryptocrystalline and blue-black to black, becoming blue on exposure. The mineral is readily soluble in cold water to a deep blue solution. It has never been analyzed quantitatively and its composition has been assumed to be $MoO_2.4MoO_3$. Recent analysis of material from near Ouray, Utah, has shown that the amount of molybdenum in a lower state of oxidation is insignificant and that practically all of the molybdenum is present as MoO_3.

[1] DANA, E. S. System of Mineralogy, 6th ed., p. 202. 1892.

Furthermore, the mineral is a sulphate and is not an oxide nor a molybdate of molybdenum.

The occurrence of ilsemannite near Ouray, Utah, has been investigated from the geological side by Frank L. Hess of the United States Geological Survey, who is preparing a report on this subject. The present paper, which is of a preliminary nature, aims to give briefly the mineralogical features of the blue molybdenum mineral, as the complete study has been unavoidably interrupted for a time.

The ilsemannite from Ouray, Utah, is disseminated through a rock, analysis of which shows that about 10 per cent of the sample is soluble in cold water. The analytical figures are given in Table 1.

TABLE 1

ANALYSIS OF ROCK CONTAINING DISSEMINATED ILSEMANNITE, FROM NEAR OURAY, UTAH

		Analysis	Ratios	Ratios after deducting melanterite	
Insoluble in water		90.50			
Soluble in water	FeO	0.99	0.014		
	MoO_3	2.37	0.017	0.017	1
	MoO_2	trace			
	SO_3	2.64	0.033	0.019	1
	H_2O (by diff.)	3.50	0.194	0.097	5
		100.00			

The water-soluble portion contains iron sulphate, and the consumption of permanganate in titrating this solution exactly equals the amount of iron (as ferrous iron) determined gravimetrically. There is present, therefore, only an undeterminable amount of molybdenum in a lower state of oxidation. Wells[2] found similarly that the deep-blue mine water from the Lucania tunnel, Idaho Springs, Colo., although containing 7.98 grams MoO_3 per liter, contained only an undeterminable trace of MoO_2. The coloring effect of this trace of MoO_2 seems to be very intense.

[2] Quoted by HORTON, F. W., in *Molybdenum: its ores and their concentration.* U. S. Bur. Mines Bull. 111, p. 15. 1916.

Tests made on ilsemannite from other localities show that iron sulphate is present in all specimens examined, and if, therefore, the figures for melanterite are deducted from the ratios given above, the remainder gives the ratio of $MoO_3:SO_3:H_2O$ as 1:1:5. It is suggested, therefore, that the formula of ilsemannite be taken as $MoO_3.SO_3.5H_2O$ until further quantitative analysis, on pure material, shows a difference. The analysis of the deep-blue mine water from Idaho Springs, Colo., approximates closely, after deducting for other sulphates, to a ratio of 1:1 for $MoO_3:SO_3$, and this mine water is probably a solution of ilsemannite. A sulphate of molybdenum, $MoO_3.SO_3$, has been prepared artificially.

A specimen from Saxony showed abundant ilsemannite mixed with iron sulphate, and selected portions of the blue mineral gave a strong sulphate reaction and showed only a small amount of iron. Another specimen from Carinthia gave a strong sulphate reaction with no ferrous iron and only a trace of ferric iron. These two specimens were kindly loaned by Col. Washington A. Roebling, of Trenton, N. J. The ilsemannite from Cripple Creek, Colo., described by Lindgren and Ransome[3] gives likewise a strong sulphate reaction. It is suggested that what is called a new molybdenum mineral by Horton[4] is either a yellow sulphate of iron or yellow molybdite impregnated with a blue solution of ilsemannite, the combination of the blue and yellow producing green. Such a green coating was observed on the specimen from Cripple Creek, Colo.

The origin of ilsemannite should be studied in detail for each occurrence, but the following suggestions may be offered:

1. Oxidation of molybdenite: $MoS_2 + O_9 + 6H_2O = MoO_3.SO_3.5H_2O + H_2SO_4$.

2. Oxidation of jordisite,[5] the colloidal form of molybdenite, the powdery character of jordisite allowing of more ready oxidation and alteration.

[3] Lindgren, W., and Ransome, F. L. *Geology and gold deposits of the Cripple Creek district, Colorado.* U. S. Geol. Survey Prof. Paper 54, p. 124. 1906.

[4] Horton, F. W. Op. cit., p. 15.

[5] Cornu, F. Zeitschr. Chem. Indust. Kolloide, 4: 190. 1909.

3. Decomposition of molybdates, the explanation offered for the formation of ilsemannite from wulfenite at Bleiberg, Carinthia.

4. The decomposition of a molybdenum-bearing silicate, such as molybdosodalite.[6]

The analysis of ilsemannite from Utah shows a percentage of 2.37 MoO_3 for the sample of rock taken. Other samples showed only about half as much molybdic oxide, but the average percentage of water-soluble molybdenum contained in the rock as a whole is not known.

BOTANY.—*Seedling morphology in palms and grasses.* O. F. Cook, Bureau of Plant Industry.

Morphological interpretation of the grass embryo has developed a voluminous and highly technical literature, a recent contribution being a paper by Worsdell on The Morphology of the Monocotyledonous Embryo and of that of the Grass in particular.[1]

From the standpoint of the palms, the effort to interpret the first leaf-sheath of grasses, the so-called coleoptile, as a part of the cotyledon appears artificial and unnecessary. Worsdell carried this idea to the extreme of identifying the coleoptile with the ligule of a very highly specialized cotyledonary leaf, the nursing foot, or scutellum, with the blade, and the epiblasts with auricles of the blade.

Comparison with the germination of the palms would make such assumptions unnecessary. It is possible to interpret the seedling organs of palms in simple terms of general morphology that writers on grasses leave out of account. The grass embryo has its specialized features, but there can be no advantage in undue elaboration of the differences.

THE PLANT BODY METAMEROUS

The general fact to be kept in mind is that plant bodies are metamerous, that is, made up of phylogenetically and mor-

[6] Described by Zambonini, F. Mineralogia Vesuviana, p. 254. 1910.

[1] Annals of Botany, **30**: 509–534, October, 1916, with bibliography.

phologically equivalent units of structure, the phytomers, as they have been called. A typical, vegetative phytomer is represented by one of the internodes, or sections of a jointed plant stem, together with the roots that may grow from the surface of the internode and the leaf that it bears at the distal end. A terminal bud, and usually one or more lateral buds, are formed within the sheathing base of the leaf, so that a succession of phytomers can be produced.[2]

Cotyledons are leaves of the first phytomers of young plants, the internode element of this phytomer being represented by the so-called hypocotyl, or basal joint of the plant stem, from which the roots grow down. Other joints of the stem send out roots from lateral surfaces. In some palms the roots are confined to the ends of the internodes but in others they grow adventitiously from any part of the surface.

GERMINATION IN PALMS AND GRASSES

Germination commonly begins with the elongation or downward growth of the hypocotyl and the roots. In palms and grasses, the development of the hypocotyl is relatively slight, a biological deficiency that has been made good in different ways in the two groups. The grasses have small seeds which are easily buried, and germinate quickly in a few days, whereas the palms have the largest of all seeds and germination is a process of weeks or months.

The method of germination of some of the large-seeded palms is most remarkable. The function of the hypocotyl in dicotyledonous plants is performed by a petiole or elongated base of the cotyledon, which grows out of the seed and burrows into the soil, taking the plumule with it. In some cases the cotyledon elongates to the extent of several inches. In the germination of the so-called double-coconut *Lodoicea seychellarum*, the largest of all seeds, the cotyledon attains a length of several feet. After the burrowing cotyledon ot a palm has grown to its full length, the tip, representing the hypocotyl, sends out roots,

[2] Cook, O. F. *Morphology and evolution of leaves.* Journ. Washington Acad. Sci., **6**: 537. 1916.

and splits open on one side for the emergence of the plumule. Thus the cotyledon itself, like all of the subsequent leaves of the palms, has a sheathing base.

After being planted by the elongated burrowing base or petiole of the cotyledon, the palm embryo encounters the same problem of pushing its way to the surface of the soil as does the grass embryo, and has solved it in a similar way, by specializing the lower joints of the plant axis. Instead of producing complete, bladed leaves, the internodes immediately above the cotyledons of palms and grasses produce only small, rudimentary leaves, in the form of narrow, cylindrical bladeless sheaths.

The germination of the maize plant shows the extent to which these specializations have been carried in grasses. Even when the seeds are buried under several inches of soil the bladeless first leaf, or coleoptile, may be carried up to the surface by the growth of a specially elongated root-bearing section of the axis. The extreme cases are found in some of the varieties of maize grown by the Hopi, Navajo, and other native Indian tribes of the dry table-lands of New Mexico and Arizona.[3]

The more or less elongated section of the stem below the coleoptile of the maize is called by some writers *hypocotyl*, by some *epicotyl*, and by still others *mesocotyl*, the name depending upon whether the organ was supposed to be a part of the cotyledon or a distinct morphological element above or below the cotyledon. Some others have looked upon the coleoptile as the cotyledon. If both the scutellum and the coleoptile are considered as parts of the cotyledon, the intervening structure has to be reckoned likewise as a part of the cotyledon. On this basis, mesocotyl would be the more appropriate term, and it may also be justified on the ground that the coleoptile has analogy, if not homology, with the cotyledons of other plants.

A distinct name, mesocotyl or some other, is needed, because this part of the axis, in producing roots along its entire length instead of only at the upper end, is unlike the other internodes and there are differences of internal structure. That the meso-

[3] COLLINS, G. N. *A drought-resisting adaptation in the seedlings of Hopi maize.* Journ. Agr. Research, 1: 293–301. 1914.

cotyl is different, is not, however, a sufficient reason for supposing that it is not the morphological equivalent of the other internodes. To consider that an internode may be rhizophorous along its entire length is only to recognize in the seedlings of some of the grasses a condition that is common among palms, and is retained through the entire life-history. To hold that a root-bearing section of the axis above the scutellum is a part of the cotyledon, seems a much more violent assumption than to suppose that the internode of the coleoptile has retained the primitive root-bearing function. To deny that the mesocotyl represents the internode of the coleoptile is to assume that this internode has been suppressed and a new organ intercalated in its place.

EPIBLASTS AS RUDIMENTARY PHYTOMERS

Reduction or suppression of the leaf or of the axial element of the phytomer being very common forms of specialization, the epiblasts may be taken to indicate one or two rudimentary internodes above the scutellum. Thus the mesocotyl would belong to the third or fourth phytomer of the seedling, the one that produces the first leaf sheath, the coleoptile. It is much easier to believe that epiblasts represent rudiments of suppressed phytomers than that they hark back to auricles of a formerly more highly developed cotyledonary leaf. The so-called auricles of grass leaves are so distinctly a part of the ligular specialization that their separate survival as epiblasts seems highly improbable.

A tendency of different organs to become more alike has often to be recognized, but this idea of morphological convergence would hardly justify the assignment of parts of a foliage leaf to represent the scutellum, coleoptile, and epiblast. In order to consider these organs as parts of the same leaf it has to be assumed that the sheathing base, representing the most primitive element of leaf structure, has been suppressed, while the blade, ligule, and auricles have been retained.

PROPHYLLUM AND COLEOPTILE

The prophyllum of palms appears generally to be a double organ, formed by the concrescence of bladeless sheaths representing the reduced leaves of two very short basal phytomers of the inflorescence or the branch, in the few palms that produce branches. Usually only the basal sheath of the inflorescence shows the double or bicarinate condition, but in inflorescences of the small, trunkless palms that constitute the genus Sabal all of the spathes are compressed and bicarinate like the first.

Prophylla of grasses resemble those of palms except that they are not united on the side away from the main axis, but this condition also occurs in palms, having been observed in 1915 in a Peruvian species of Ceroxylon. Here the sides not only failed to meet in the middle but often the insertions were not directly opposite. In grasses as well as in palms the prophylla are always bicarinate and bilabiate, or biapiculate. Still more significant facts have been noted by Mr. G. N. Collins, that when buds or branches develop inside the prophylla their position is lateral, or opposite one of the carinae, instead of in the median position that would represent the axil if the prophyllum were a simple organ. A few cases were found where two buds developed in the same prophyllum, one on each side, a still more definite indication that two metamers are represented.

If it be admitted that the prophyllum is a double organ, indications of duplicity in the coleoptile do not require such an interpretation as Worsdell has proposed in homologizing the coleoptile with the ligule of the foliage leaf. Metaphanic anticipation of a double organ like the prophyllum in the seedling stage may be considered, or the alternative possibility that a double organ of the seedling is reproduced in the prophylla of the branches. A double coleoptile would mean that the leaves of two primitive phytomers are involved, one probably the leaf of the internode represented by the mesocotyl, the other a leaf whose internode element has been suppressed. But whether single or double, the coleoptile may be supposed to represent the entire sheath of the foliage leaf, not merely the ligule.

This is in line with the suggestion already made in relation to the epiblast. If we consider that two reduced leaves are united in the coleoptile, a similar reduction of leaves immediately above the cotyledon would not seem improbable. The epiblasts would be in the nature of hypophylls like those that occur on seedlings of the avocada, *Persea americana*, for several inches above the cotyledons. Epiblasts may be considered as rudimentary leaves without supposing that they have been in the past equal partners of the cotyledons, and without adopting the theory that the monocotyledons plants have been derived directly from dicotyledons. Too much stress appears to have been laid upon the number of the cotyledons, in view of the fact that variations are of rather frequent occurrence, and that the two series of plant families approximate rather closely when such groups as the Araceae, Artocarpaceae, and Piperaceae are considered.

As the metamerous organization of the plant body is especially noticeable in these more primitive members of the two series, there is the greater reason to take this feature into account in attempting to reach a morphological understanding of special structures and functions. The principle of metamerism yields a conception of the plant body as made up of equivalent units, instead of as an axis with leaves and other appendages attached.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

RADIATION.—*The emissivity of straight and helical filaments of tungsten.* W. W. Coblentz. Bureau of Standards Scientific Paper No. 300 (Bull. Bur. Stds., **14**: 115–131). 1917.

In the present investigation the radiation both from the inside and from the outside of the turn of a helically wound tungsten filament in an atmosphere of nitrogen was studied. It was found that the intensity of the radiation from within the turn of the helix is from 90 to 100 per cent greater than from a similar area on the outside of the turn. This is accounted for on the basis of multiple reflection within the helix. This reflection modifies the quality of the light so that it is redder than the light from the outside of the turn. The close agreement between the observed infra-red measurements of the radiation from within the helix and the computed values (obtained on the basis of multiple reflection and the reflectivity of tungsten) confirms the belief that the phenomenon is the result of multiple reflection. Tests made with a nicol prism, showed that the light from within the filament is highly polarized. This and the infra-red energy measurements both indicate that the quality of the radiation emitted differs from that of a black body. There is no indication that the temperature within the helix is higher than on the outside of the turn. A difference in temperature of 200° would be required to account for the observed difference in brightness. W. W. C.

CALORIMETRY.—*An aneroid calorimeter for specific and latent heats.* Nathan S. Osborne. Bureau of Standards Scientific Paper No. 301 (Bull. Bur. Stds., **14**: 133–157). 1917.

The principle of the unstirred or "aneroid" type of calorimeter has been embodied in an instrument especially designed for deter-

minations of the specific heat and latent heat of several substances in general use as refrigerating media. Heat developed electrically in a coil located in the central axis of the cylindrical shell comprising the calorimeter is distributed by conduction to the calorimeter and contents whose initial and final temperature, when in thermal equilibrium, are measured by a platinum resistance thermometer. Heat from other sources is excluded by enveloping the calorimeter with a metal jacket separated from it by an air space and keeping this jacket during measurements at the same temperature as the calorimeter surface, using multiple thermocouples to indicate this equality. The calorimeter is adapted for use between $-50°$ and $+50°$C. and for pressures up to 70 atmospheres. The method of manipulation in making measurements of heat capacity is described, and the results of an extended series of observations to determine the heat capacity of the empty calorimeter are given.

N. S. O.

PHYSIOLOGICAL OPTICS.—*The relative sensibility of the average eye to light of different colors, and some practical applications to radiation problems.* W. W. COBLENTZ and W. B. EMERSON. Bureau of Standards Scientific Paper No. 303 (Bull. Bur. Stds., **14**: 167–250) 1917.

In the present investigation the methods are practically the same as used by previous experimenters. In the visual measurements, the spectral light was compared with a standard white light both by means of a flicker photometer and by means of an equality of brightness photometer. The source of white light was a standarized vacuum tungsten lamp. A cylindrical acetylene flame was used as a source of spectral light. The distribution of energy in the spectrum of the acetylene flame was determined with great care. Visibility curves were obtained on 130 persons, of which number 7 were known to be color blind. The visibility curve of the average eye is wider than previously observed. A mathematical equation of the average visibility is given and applications of these data to physical photometry are made. It is shown that the eye responds to light having an intensity less than 1×10^{-16} watt.

W. W. C.

GEOLOGY.—*Structure of the Vicksburg-Jackson area, Mississsippi.* OLIVER B. HOPKINS. U. S. Geological Survey Bulletin 641–D. Pp. 93–120, with 1 plate. 1916.

The object of this report is to show which of the areas in west-central Mississippi that were examined by the Survey are considered

favorable and which unfavorable for the occurrence of oil, to discourage drilling in the unfavorable localities, and thus to aid those interested in making conclusive tests to determine the presence or absence of oil and gas.

All the rocks of the area are sedimentary in origin and are relatively young, the exposed rocks ranging in age from Claiborne (Eocene) to Recent. Of these formations the loess and the Jackson underlie by far the greater part of the area, and the Vicksburg and Catahoula formations and the terrace sand and gravel underlie smaller areas.

The general structure of the Gulf coastal plain is simple. A series of beds slopes gently southward and passes successively deeper and deeper beneath more recent deposits toward the coast. This general dip toward the coast is interrupted by local steepening or flattening and in a few places by a reversal in direction. These irregularities of dip, which are of greatest significance in the accumulation of oil and gas in valuable pools, are well illustrated in the Vicksburg-Jackson area. The geologic structure is represented on a map by contours on the Vicksburg limestone. The possibilities of oil and gas occurring in the area are discussed and the most promising areas for prospecting are pointed out. R. W. S.

TECHNOLOGY.—*The effusion method of determining gas density.* Junius David Edwards. Bureau of Standards Technologic Paper No. 94. Pp. 30. 1917.

In cooperation with a number of men employing this method in the natural gas industry a series of experiments was made using their apparatus under field conditions. It was found that results in error by more than 10 per cent were not unusual. The theory of the effusion process was studied, and the effect of differences in physical properties upon the relative rates of effusion of air and hydrogen, argon, methane, and carbon dioxide at different pressures was determined. Also observations were made on the effect of the effusion pressure, the *confining medium* and the shape and size of the orifice. It is very important that the orifice be of the proper size and shape. It has been shown that the apparent specific gravity, as determined by this method, can be varied within rather wide limits by changing the conditions. However, by the observance of certain precautions in the construction and use of the apparatus, it is possible to secure results accurate to about 2 per cent. Recommendations have been made as to the most suitable type and form of apparatus. J. D. E.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 318th meeting was held at the Cosmos Club, March 28, 1917.

INFORMAL COMMUNICATIONS

C. J. Hares: *Gastroliths in the Cloverly formation.* Gastroliths were found in the summer of 1916 in the Cloverly formation in the northeast portion of the Bighorn Basin, Wyoming, at about the base of Pryor Mountains in Montana. These gastroliths occur in the shale portion of the Cloverly, between the Pryor conglomerate member at the base and the Greybull sandstone member. The gastroliths occur in such large quantities and so large individually that I was led to question the theory that they were polished in the stomachs of dinosaurs and plesiosaurs, as advocated by Williston and others. The shale, however, does carry some bones of these animals. A large representative collection was made; some of the specimens are very highly polished, and others polished scarcely at all. But if the highly polished ones are true gastroliths, then it is probable that the unpolished ones are likewise gastroliths. Some of the stones are over 6 inches long. The material consists mostly of highly siliceous rocks, jasper, chalcedony, quartzite, etc.

Discussion: C. W. Gilmore spoke of the definite association of similar stones with single skeletons of plesiosaurs.

REGULAR PROGRAM

C. J. Hares: *The southern extension of the Eagle sandstone and its relation to the Niobrara shale in Wyoming.* In the summer of 1916, while mapping the Elk Basin and Byron oil fields and an area extending from Bridger, Montana, to Greybull, Wyoming, detailed stratigraphic information was obtained, showing the correlation of the Upper Cretaceous formations of Montana with those of Wyoming. The classic Cretaceous section of Montana, as worked out by Hayden, Weed, Stanton, and Hatcher, along the Musselshell River, has been carried southward by the detailed work of Lloyd, Bowen, and Hancock to the Yellowstone River. The formations so mapped include the Colorado shale, the Eagle sandstone, Claggett shale, Judith River formation, and Bearpaw shale. The upper part of the Eagle and the Judith River are mostly of fresh water origin, the others in the main are marine.

On the other hand the more or less classic section of southern and central Wyoming, as established by King, Hayden, Darton, Stanton, Knowlton, Veatch, and others, has been carried by detailed mapping by Bowen, Barnett, Wegemann, Lupton, Hares, and others, northward to the northern boundary of Wyoming and even beyond to the Yellowstone River. The area along the Montana-Wyoming State line may be likened naturally to the closing point on an engineer's survey, and it is found that the formations of the two classic sections join up for the most part, as previous general correlations have been made, but vary in certain details.

The southern and central Wyoming section includes the following formations in the Colorado and Montana group, from the bottom up, the Thermopolis shale, Mowry shale, Frontier formation, Carlile shale, Niobrara shale, Steele shale, Mesaverde formation, and Lewis shale. In the detailed work it was found that the Thermopolis, Mowry, Frontier, and Carlile are recognizable units as far north as the Yellowstone River and possibly beyond, and that along the Montana-Wyoming State line the Niobrara, as mapped in central Wyoming by Wegemann, Barnett, Bowen, and Hares, falls about 1400 feet below the top of the Colorado group and the base of the Eagle sandstone. The Steele shale along the same line includes the upper part of the Colorado shale, the Eagle sandstone, and the lower part of the Claggett formation. The Mesaverde corresponds to the upper part, or Parkman sandstone member, of the Claggett and the Judith River. The Lewis shale has been recognized as far north as the Wind River basin and Salt Creek, Wyoming.

It has been fairly definitely established that the type Eagle sandstone includes in its lower part the massive cliff-forming sandstone at Park City and Billings, but about 100 feet below the massive sandstone is a thin sand, 10 to 40 feet thick, which contains an Eagle fauna. This lower sand is rim-forming from Park City to Elk Basin and the Shoshone River, but from there south it is represented, as is the remainder of the Eagle formation, by thin-bedded sandstones and arenaceous shales. This sand has been called the Elk Basin sandstone member of the Eagle. Further, it seemingly corresponds to the Shannon sandstone as mapped in the Casper-Salt Creek region, and it may be found still farther south. The body of shale between this horizon and the Mesaverde as a rule is light-colored and sandy, whereas the shale below the Elk Basin sandstone member of the Eagle and above the Carlile shale is darker colored, contains thin limy layers, and concretions that weather reddish-brown. The southern extension of the Eagle sandstone into Wyoming seems to represent the thinning out to a feather-edge of a recessional sand that is massive, thick, and resistant in central Montana. It has been found that the upper part of the Claggett shale grows more and more sandy as it is followed southward into Wyoming and includes about 540 feet of massive sandstones and thin-bedded shales of which at least the lower part is marine; and, further, that this ridge-forming sandstone—called the Parkman sandstone member of the Claggett—corresponds to the lower part of the Mesaverde, also called the Parkman sandstone mem-

ber of the Mesaverde, as mapped in central Wyoming, and is also present in the southern part of the Bighorn Basin. The Judith River, as traced southward, includes the lower part of the Meeteetse formation and corresponds to the upper part of the Mesaverde of central and southern Wyoming. The Bearpaw shale can be recognized as a marine shale as far south as Elk Basin, and marine sandstones are recognized as far south as the Shoshone River and Greybull. Further detailed mapping will probably establish the fact that the Bearpaw corresponds in whole or in part with the Lewis shale of the southern areas. The work also shows that the formations as a whole are thinner in the northern and central Wyoming areas. Apparently the source of sediments was chiefly from the west or southwest direction. This is borne out in part by the fact that on the west side of the Bighorn Basin no purely marine beds are present above the base of the Mesaverde.

Discussion: C. F. Bowen spoke of the feathering of the Eagle sandstone near the Musselshell River. C. H. Wegemann said that about 30 miles southeast of Billings the Eagle sandstone disappears among shales. T. W. Stanton called attention to the almost perfect correlation which recent detailed study had made possible.

Willis T. Lee: *Relations of the Morrison and Sundance formations.* Sedimentary rocks of variable character and thickness, belonging to the Sundance formation (marine Jurassic) occur in most places along the eastern foothills in Colorado as far south as Morrison, where they are 10 to 20 feet thick. They have heretofore been included in the Morrison formation but are now known to lie unconformably below the lowest dinosaur beds. These Jurassic rocks lie unconformably on Permian red beds (Lykins). Farther to the south, beds of gypsum, now referred to the Lykins, may in fact represent the horizon of the marine Jurassic. The Morrison formation rests unconformably on the Jurassic, or on the Permian where the Jurassic is absent. In the upper part of the Morrison at the type locality of this formation a small collection of fossil plants, which F. H. Knowlton has determined to be highly developed dicotyledons of Cretaceous age, was obtained. Although the plants were found above the highest known dinosaur horizon, no question has been raised as to the propriety of including the plant horizon in the Morrison formation, nor is it probable that any geologist familiar with the section in the field will raise such a question unless he discards the accepted definition and redefines the formation. These rocks, together with the dinosaur beds a few feet lower, were once classed as Jurassic because of the supposed Jurassic affinities of the dinosaurs; later as "Jurassic or Cretaceous;" and finally as "Lower Cretaceous (?)." The plants recently found are of such character as to place the rocks containing them definitely in the Cretaceous and at a horizon considerably above the base of the system. As the Dakota sandstone, usually classed as basal Upper Cretaceous, occurs above the rocks containing the plants, it is appropriate to class those between it and the Jurassic as lower Cretaceous. The Morrison formation has been regarded as a stratigraphic unit although probably

representing a long time. However, as just stated, the Jurassic beds below the lowest dinosaur horizon were incorrectly included, and there is a possibility of further restriction of the formation. But, until it is shown that the plant horizon is not properly included, the plants must stand in favor of the Cretaceous age of the Morrison.

Discussion: C. H. WEGEMANN mentioned conglomeratic sandstone above the Morrison. T. W. STANTON said that typical Dakota forms occur in eastern Nebraska, and that four of these species are found in See's Morrison.

ALFRED H. BROOKS: *Memorial to C. Willard Hayes.* (Published in the Bulletin of the Geological Society of America, **28**: 81–123.)

The 319th meeting was held at the Cosmos Club, April 11, 1917.

INFORMAL COMMUNICATIONS

G. W. STOSE: *Corals growing along the coast of Delaware.* The finding of corals as far north as Delaware raises interesting questions as to conditions of environment, means of distribution, effects of environment on size, etc.

REGULAR PROGRAM

DEAN E. WINCHESTER: *Oil-shale in the United States.* Oil-shale is an argillaceous or shaly deposit from which petroleum may be obtained by distillation but not by treatment with solvents. It must be mined like coal and then heated before its oil is made available. In the United States there are black shales, ranging in age from Devonian to Eocene, which will yield oil when heated, but so far as yet examined the oil-shale of the Green River formation (Eocene) of Colorado, Nevada, Utah, and Wyoming is by far the richest, although shale of Carboniferous age in southwestern Montana has been found to yield as much as 24 gallons of oil per short ton, and some shales associated with coal beds in the coal fields of the eastern part of the United States yield even more. Cannel coal and cannel shale are also rich. Good oil-shale is black or brownish black in color, except on weathered surface, where it is bluish gray to nearly white. The shale is fine-grained, usually slightly calcareous. It is tough and in thin-bedded specimens remarkably flexible. When freshly broken oil-shale gives off a peculiar odor like petroleum, although the rock contains but little oil that can be extracted with solvents.

Approximately 5500 square miles in northwestern Colorado and northeastern Utah are underlain by beds of oil-shale (Green River formation) thick enough to mine and apparently rich enough to warrant the development of an industry for the manufacture of shale-oil and other products. Mining conditions in the oil-shale of Colorado and Utah are much more favorable than in Scotland, where the oil-shale industry has been best developed. Crude distillation tests indicate

that the oil-shale of the Green River formation is capable of yielding more oil than the shale mined in Scotland, although the yield of ammonia (principal byproduct) may be less than that derived from the Scotch shales. Individual beds vary from place to place in thickness and character, but the apparent persistence of the individual members of the formation is remarkable.

The beds of oil-shale were laid down in fresh water which had an enormous expanse and was so deep that wave action had little effect on the sediments. The richer beds of oil-shale contain an immense quantity of vegetable matter, while the leaner beds contain much less. Algae, mosses, ferns, pollen of higher plants, fungi, and anomalous but well marked and characteristic forms of plant life are very common in the rich shale, as shown in several hundred thin sections prepared by Dr. C. A. Davis shortly before his death. Fish remains are in some places present, insect larvae, fresh-water shells, and even bird bones have been found.

It is believed that, at least in the Green River oil-shales, the oil is indigenous to the shale, being formed from the vegetal remains in the shale partly by the slow processes of nature, partly by the violent destructive distillation in the laboratory. Dr. Davis in an unpublished note says "the mineral (not organic) part of the rich bed is physically so minute that if it were the sole original material into which the bituminous matter was injected the intrusion would have greatly distorted the beds overlying the invaded ones, but no such distortion is observable. . . . If, however, the bituminous matter is held in the partly bitumified matter seen in an incompletely decomposed state in the shale, heat might decompose the parent fossil material, and petroleum in quantities proportionate to the percentages of plant remains might be produced."

Discussion: H. M. Ami spoke of extensive tests made by the Canadian government on Nova Scotian shales. Near intrusives in these shales some naturally distilled hydrocarbons have been found. The occurrence of albertite was referred to. David White compared albertite and gilsonite as to occurrence in fissures, and also compared the lamination and algal growths in playa deposits with structures in oil-shales. Winchester added that gilsonite veins seem to have originated from oil-shales. They are found in the beds above and below the shales.

E. T. Wherry: *Occurrence of calcite in silicified wood.* A specimen of silicified wood obtained from Yellowstone National Park and showing calcite crystals scattered through its mass was described. The calcites contain near their centers inclusions of well-preserved wood cells, but outwardly are clear, except for a dark "phantom" line a short distance from their surfaces. The wood cell material crowded out by the growth of the later portions of the crystals is heaped up as a dark rim around them, no pressure effects being shown by the cells outside of this rim. It is inferred that after the wood had rotted to the consistency of a wet sponge the calcite started to grow from solutions

impregnating the wood. At first the growth was so rapid that the wood cells were enclosed, as is the sand in "sand-calcites," but later it went on more slowly, giving opportunity for the foreign matter to be excluded. The "phantom" line probably marks a temporary cessation of growth. The absence of silica within the calcites, as well as other relations, indicates that the deposition of silica was subsequent to crystallization of the calcite.

Discussion: D. F. HEWETT mentioned the occurrence in certain clays and residual soils of calcite grains surrounded by little quartz grains, as though the quartz had been pushed aside by the growing calcite. DAVID WHITE outlined different plausible explanations of the structures described by Wherry.

R. S. BASSLER: *The value of microscopic fossils in stratigraphy.* The speaker based his remarks upon the Early Tertiary Bryozoa of North America, a monographic study of which has just been completed for the U. S. Geological Survey. He showed with the aid of specimens and lantern slides the methods of collecting, the preparation for study, and the characters employed in the classification of these microscopic fossils. Until recent years these fossil bryozoa have been considered more as perforated stones than as well organized creatures in which the perforation and ornamentation of their surface had definite physiological purposes. The relation between the morphological and skeletal variations and their physiological purposes was discussed, and finally the stratigraphic results, particularly in intercontinental correlation, were described.

Discussion: E. O. ULRICH emphasized the fact that because these fossils are studied microscopically, *specific* differences can readily be established, and only specific characters are of definite time value.

H. E. MERWIN, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 121st regular meeting of the Society was held in Assembly Hall of the Cosmos Club at 8 p.m., Tuesday, May 1, 1917; 39 members present. The meeting was called to order by the President. Mr. BURT A. RUDOLPH and Mr. HORACE W. TRUESDELL, Scientific Assistants in the Office of Fruit Disease Investigations, and Mr. GLENN C. HAHN, Office of Forest Pathology, were elected to membership in the Society.

The regular program was devoted to a *Symposium on the District flora.* Prof. A. S. HITCHCOCK gave an outline of the plan of the flora. The flora of Washington has been studied for nearly 100 years. In 1831 Brereton's *Prodromus of the Flora Columbiana*, was published. Ward's Flora, or *Guide to the Flora of Washington and Vicinity*, was published in 1881 and several supplements have since been issued. In 1906 a mimeograph list of the vascular plants of the District of Columbia and vicinity was prepared by P. L. Ricker, Chairman of the Botanical Seminar. The Seminar Committee on Spermatophyta con-

sisted of A. S. Hitchcock, Agnes Chase, and J. H. Painter Early in 1915 Frederick V. Coville and A. S. Hitchcock undertook to organize a study of the District flora on the cooperative basis and the plan was reported to the Society in 1915. During 1915 and the early months of 1916 keys of nearly all the families were prepared. These keys were mimeographed and distributed to contributors. Mr. Coville has since withdrawn from active leadership and the flora is now under the direction of Mr. Hitchcock and Mr. P. C. Standley. A total of twenty-five contributors are at work on the different groups. A preliminary manuscript is to be turned in by June 1 and the manuscript completed by November 1 of this year.

Mr. Edgar T. Wherry, at the invitation of the Society, gave a paper on *Geological areas about Washington*. Mr. Wherry not being able to be present, the paper was read by Mr. Hitchcock. The most prominent geological feature is the Fall Line, which separates the Piedmont Plateau on the northwest from the Coastal Plain on the southeast. This line was named from the fact that the rivers and smaller streams flowing southwestward toward the sea often have waterfalls or rapids at or near this line. Above this the valleys are narrow and steep-sided and the contour lines close together, while below it the valleys are broad and open and the contour lines wide-spaced. The geological formations of the Piedmont Plateau are chiefly crystalline gneisses of early periods, among which may be mentioned the Carolina gneiss, granite gneiss, diorite, biotite granite, and basic igneous rocks, including gabbro, meta-gabbro, and serpentine. The Coastal Plain is occupied by unconsolidated gravels, sands, and clays deposited during successive advances of the sea during Cretaceous, Tertiary, and Quaternary periods. Gravels also occur to some extent as cappings on the hills along the edge of the Piedmont. Bogs are frequent in the Coastal Plain and rare on the Piedmont. Lime is present in the soils of the Piedmont through concentration by means of accumulations of leaf mold, although there are no highly calcareous rocks in the vicinity. Acid soils are predominant on the Coastal Plain. The speaker called attention to the condition of the flora of the two regions which he illustrated by the distribution of the species of Liliales. Those species limited to calcareous soils found chiefly on the Piedmont Plateau are *Allium tricoccum*, *Unifolium canadense*, and *Trillium sessile*. Those limited to noncalcareous or acid soils found chiefly on the Coastal Plain are *Aletris farinosa*, *Tofieldia racemosa*, and *Stenanthium gramineum*. The other species grow throughout the region and show no marked soil preference.

Mr. George B. Sudworth spoke on the subject *Distribution of trees in the floral area*. Mr. Sudworth traced briefly the history of the study of the trees of the District of Columbia. Lists have been prepared at various times by Ward, Knowlton, Holm, and Steele. There are about 400 species and varieties of native and exotic trees growing within the District, many of which are in Government reservations. Of the 140 species of native trees the broad-leaved trees of the District number about 122 species and varieties and are therefore greatly in

excess of all others. No arborescent representatives of the monocotyledons are found growing naturally within the District. The oaks are the most prominent among the broad leaved trees of the District and constitute from one-half to three-fourths of the upland forest cover. They consist largely of black, red, and white oak. The most prominent conifer of this region is *Pinus virginiana*. Two naturalized trees of the District deserving special mention are the Japanese paper mulberry and the Ailanthus or Tree of Heaven. Both were introduced from China and Japan and are the most thoroughly established of the exotic trees.

Mr. FREDERICK V. COVILLE discussed *Humus as a factor in plant distribution*. Mr. Coville exhibited two samples of organic matter, the one, brown, only partially decomposed remains of the leaves and roots of laurel and oak, which make up a large proportion of the acid humus of this section; the other a black, fully-reduced, nonstructural leafmold, the reduction in this case being favored by the large amount of calcium contained in the leaves from which the mold is formed. The lime content of the sample of leafmold shown was six per cent, expressed as calcium oxide. Mr. Coville discussed the effect of these two types of organic matter on the distribution of plants.

Mr. P. L. RICKER discussed *Collecting and preparing specimens*. Mr. Ricker called attention briefly to the older methods of collecting and drying plants and suggested the advisability of using corrugated driers as well as neat portfolios, especially for field work. Where corrugated driers are used the plants can be dried without change of blotters but, in case of rainy weather, the use of artificial heat is recommended.

Following this the various papers were discussed informally by the members on the program and by Messrs. SAFFORD, BEATTIE, NORTON. WAITE, LEWTON, and SHANTZ.

H. L. SHANTZ, *Corresponding Secretary*.

CONTENTS

Original Papers

Page

Geophysics.—Thermal gradient of Kilauea Lava Lake. T. A. Jaggar, Jr. 397

Crystallography.—The thermodynamic reversibility of the equilibrium relations between a strained solid and its liquid. F. E. Wright and J. C. Hostetter 405

Mineralogy.—Ilsemannite, hydrous sulphate of molybdenum. Waldemar T. Schaller 417

Botany.—Seedling morphology in palms and grasses. O. F. Cook 420

Abstracts

Radiation 426
Calorimetry 426
Physiological Optics 427
Geology 427
Technology 428

Proceedings

The Geological Society of Washington 429
The Botanical Society of Washington 434

VOL. VII

AUGUST 19, 1917

No. 14

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

Vol. VII | AUGUST 19, 1917 | No. 14

PHYSICS.—*Note on the vibration frequencies of elastic systems.* M. D. Hersey, Bureau of Standards. (Communicated by Louis A. Fischer.)

Introduction. This paper deals with the free vibrations of perfectly elastic bodies. Damping and forced vibrations are excluded from consideration. The purpose is to present the most complete statement, regarding the vibration frequencies of such bodies, that is possible in advance of any knowledge of the geometrical shape of the bodies.

The paper is referred to the attention particularly of persons engaged in acoustics, or in the development of time-keeping devices, or in problems of engineering construction where resonance has to be avoided. Still others, however, may find the paper suggestive in showing what can be done by combining dimensional reasoning with ordinary physical reasoning, in cases where either one alone would be fruitless.

The reasoning is analogous to that of a previous paper entitled The Theory of the Stiffness of Elastic Systems,[1] to which it may be regarded as a sequel, and to which reference must be made for the general conceptions and definitions involved. For convenience, however, the following statement of notation is given:

$$\theta = \text{temperature}$$

$$E = \text{Young's modulus}; \quad \alpha = \frac{1}{E}\frac{dE}{d\theta}$$

[1] Journ. Wash. Acad. Sci., 6: 569–575. 1916.

μ = shear modulus; $\quad \beta = \frac{1}{\mu}\frac{d\mu}{d\theta}$

L = length; $\quad \gamma = \frac{1}{L}\frac{dL}{d\theta}$

m = mass; $\quad \rho$ = density

σ = Poisson's ratio

$\Phi = \Phi(\sigma)$; $\quad \Phi' = \frac{d}{d\sigma}\Phi(\sigma)$; etc.

$F = F(R, \sigma)$; $\quad F' = \frac{\partial}{\partial\sigma}F(R, \sigma)$

$R = \frac{m_1}{m_1 + m_2}$; $\quad \eta = \frac{S_1}{S_1 + S_2}$

Subscripts 1 and 2 refer to the members of a coupled system.

S = stiffness (ratio force to displacement)

S_t = torsional stiffness (ratio moment to angle)

n = frequency of free vibration

$\dot{n} = \frac{1}{n}\frac{dn}{d\theta}$; $\quad \dot{S} = \frac{1}{S}\frac{dS}{d\theta}$; etc.

c, C, C_t, C_1, C_2, C_{12} = dimensionless "shape factors," i.e., constants fixed by Poisson's ratio and the generalized shape.

The most important results of this paper are to be found in the four formulas (1), (4), (11), and (12), giving respectively the frequency of a single body, the change in frequency with temperature, the frequency of a coupled system, and the change in this frequency with temperature.

General formulas for frequency of a single body. The vibration frequency for all bodies of the same generalized shape (it will be recalled that this implies not only geometrical similarity but also a similar distribution of density and the other properties of the material) may be written

$$\left.\begin{aligned} n &= \frac{1}{L}\sqrt{\frac{E}{\rho}}\,\Phi_0(\sigma) = \frac{1}{L}\sqrt{\frac{\mu}{\rho}}\,\Psi_0(\sigma) \\ &= \sqrt{\frac{LE}{m}}\,\Phi(\sigma) = \sqrt{\frac{L\mu}{m}}\,\Psi(\sigma) \end{aligned}\right\} \qquad (1)$$

The first two results come at once from dimensional reasoning on the assumption that the absolute size L, the density ρ, together with any two of the three elastic constants E, μ, and σ, form a complete set of independent variables. Those two results, ex cept for the explicit mention of Poisson's ratio, will be familiar to any one who has consulted Lord Rayleigh's writings on Sound. The transition to the last two results is obvious, and these will be more useful for some of the present purposes, because they involve a smaller number of quantities that are affected by temperature. This happens because of the physical fact that the mass of a body does not sensibly alter with temperature, whereas both the length and density do. The functions Φ_0, Φ, etc., are unknown, but if necessary could be determined by model experiments; thus, for example, Φ_0 would be found by plotting observed values of $n\, L \sqrt{\frac{\rho}{E}}$ against known values of σ.

General formula for change in frequency of a single body with temperature. Differentiating the second part of (1) logarithmically, treating m as a constant, and simplifying mathematically without introducing any further physical information, gives

$$\left.\begin{aligned} \dot{n} &= \frac{\Phi'}{\Phi}\frac{d\sigma}{d\theta} + \tfrac{1}{2}(\alpha+\gamma) \\ &= \frac{\Psi'}{\Psi}\frac{d\sigma}{d\theta} + \tfrac{1}{2}(\beta+\gamma) \end{aligned}\right\} \qquad (2)$$

In case the first term vanishes, a simple result is already available. This will happen for pure bending or stretching, for pure twisting or shearing, and for materials, if any such exist, in which Poisson's ratio does not change with temperature. For, with pure bending etc., Φ is constant, so that $\dot{n} = \frac{1}{2}(\alpha + \gamma)$; while, with pure twisting, etc., Ψ is constant, so that $\dot{n} = \frac{1}{2}(\beta + \gamma)$. In general, however, some physical law must now be made use of to evaluate $\frac{d\sigma}{d\theta}$.

The foregoing results, once it is stipulated which one of the multiple values of the several constants is to be understood by a given symbol, are perfectly applicable to heterogeneous and

anisotropic bodies; nor need the vibrations be small enough to be isochronous, provided the restriction to the same generalized shape is taken to include the deformations. But, now, for homogeneous, isotropic bodies

$$\sigma = \frac{1}{2}\frac{E}{\mu} - 1 \tag{3}$$

Differentiating (3), and substituting the result in (2), gives finally

$$\left.\begin{aligned} \dot{n} &= \tfrac{1}{2}\left[(c+1)\,\alpha - c\beta + \gamma\right] \\ \text{in which}\quad c &= 2\,(1+\sigma)\,\frac{\Phi'}{\Phi} = (1+\sigma)\,\frac{d}{d\sigma}\log\left(\frac{mn^2}{LE}\right) \\ &= 2\,(1+\sigma)\,\frac{\Psi'}{\Psi} - 1 = (1+\sigma)\,\frac{d}{d\sigma}\log\left(\frac{mn^2}{L\mu}\right) - 1 \end{aligned}\right\} \tag{4}$$

The simplicity of equation (4) is noteworthy; it shows that, for bodies made of materials for which α, β, and γ are known, the effect of temperature on frequency can be determined empirically without altering the temperature of the models; and, therefore, without any restrictions on the thermal properties of the materials the models are made of. Note that in plotting $\frac{mn^2}{LE}$ or $\frac{mn^2}{L\mu}$ against σ to determine c as a function of σ graphically, relative values are sufficient; for the existence of an unknown constant numerical factor will not alter the slope of a logarithmic plot. The same remark applies below, wherever similar expressions occur.

From (4) the condition for temperature compensation is that

$$\frac{\beta}{\alpha} = 1 + \frac{1}{c}\left(1 + \frac{\gamma}{\alpha}\right) \tag{5}$$

When γ is small compared to α (for steel γ is about 1/25 of α), $\frac{\beta}{\alpha} = 1 + \frac{1}{c}$. The two methods of compensation suggested in the previous paper—altering the composition of the material, or altering the geometrical shape of the body—are equally applicable here.

Nothing that has been said prevents Φ in (1), and therefore c in (5), from being a multivalued function, corresponding to the existence of more than one mode of vibration. From this it might be imagined that the condition for compensation (5) would not apply to more than one mode of vibration at a time; so that, if an alloy were so chosen as to compensate the fundamental, the pitch of the harmonics would alter with temperature. Closer examination shows that, for any two frequencies which stand in a constant ratio $\frac{n_1}{n_2} = k$, where k is independent of Poisson's ratio, the values of c will be identical, and compensation will be possible simultaneously, if possible at all.

The relation of frequency to stiffness. From equation (3) of the previous paper, $S = LE\,\phi(\sigma) = L\mu\,\psi(\sigma)$. Comparing with (1) above,

$$n = \sqrt{\frac{S}{m}}\, f(\sigma) \tag{6}$$

in which the form of f will depend on the generalized shape.

In passing it may be noted that the corresponding expressions in terms of torsional stiffness are sometimes preferable. It can be shown that the torsional stiffness or rigidity

$$S_t = L^3E\,\phi_t(\sigma) = L^3\mu\,\psi_t(\sigma) \tag{7}$$

so that

$$n = \frac{1}{L}\sqrt{\frac{S_t}{m}}\, f_t(\sigma) \tag{8}$$

From (7), also,

$$\left.\begin{aligned} \dot{S}_t &= (C_t + 1)\,\alpha - C_t\beta + 3\,\gamma \\ \text{in which} \quad & \\ C_t &= (1+\sigma)\frac{\phi_t'}{\phi} = (1+\sigma)\frac{d}{d\sigma}\log\left(\frac{S_t}{L^3E}\right) \\ &= (1+\sigma)\frac{\psi_t'}{\psi} - 1 = (1+\sigma)\frac{d}{d\sigma}\log\left(\frac{L^3\mu}{S_t}\right) - 1 \end{aligned}\right\} \tag{9}$$

The use of (7), for example, as a recipe for model experiments, would render unnecessary the St. Venant theory of the torsion of

prisms, so far as any practical application to the stiffness of beams or galvanometer suspensions is concerned.

Formulas for frequency of a coupled system. From (6),

$$n = \sqrt{\frac{S_1 + S_2}{m_1 + m_2}}\, f\,(\sigma) \tag{10}$$

because $m = m_1 + m_2$, and, for forces acting at the coupling, $S = S_1 + S_2$ (equation (11) of previous paper). Since f depends on the generalized shape, it will be different for different values of the ratio R, and in any case it is multivalued.

In the particular case of two bodies having the *same* generalized shape and σ, S_1 and S_2 of (10) can be replaced by their equivalents in terms of n_1 and n_2 by virtue of (6), with the result

$$n = \sqrt{R\, n_1^2 + (1 - R)\, n_2^2}\; F\,(R, \sigma) \tag{11}$$

The function F depends only on the generalized shape; not at all on the absolute sizes, masses, or elastic moduli of the bodies.

Formulas for change in frequency of coupled system with temperature. Differentiating (10) logarithmically gives, in the case of two bodies of different generalized shapes but of the *same material*,

$$\left.\begin{aligned} \dot{n} &= \tfrac{1}{2}\left[(K + 1)\,\alpha - K\,\beta + \gamma\right] \\ \text{in which}\qquad K &= \eta\, C_1 + (1 - \eta)\, C_2 + C_{12} \\ C_{12} &= 2\,(1 + \sigma)\frac{f'}{f} = (1 + \sigma)\,\frac{d}{d\sigma}\log\left(\frac{mn^2}{S}\right) \end{aligned}\right\} \tag{12}$$

and in which C_1 and C_2 are the appropriate values for the ordinary shape factor C for stiffness, as given in the previous paper; viz.,

$$\begin{aligned} C_1 &= (1 + \sigma)\,\frac{\phi_1'}{\phi_1} = (1 + \sigma)\,\frac{d}{d\sigma}\log\left(\frac{S_1}{L_1 E_1}\right) \\ &= (1 + \sigma)\,\frac{\psi_1'}{\psi_1} - 1 = (1 + \sigma)\,\frac{d}{d\sigma}\log\left(\frac{S_1}{L_1 \mu_1}\right) - 1, \end{aligned}$$

with a like expression for C_2.

For two bodies of the same material and, also, of the same generalized shape, differentiating (11) gives for K in (12) the more simple expression.

$$K = c + 2(1 + \sigma) \frac{F'}{F} \tag{13}$$

which does not require observations of stiffness.

In any event the term C_{12} vanishes when complex stresses are absent, for S will then be independent of Poisson's ratio, and f therefore a constant. But C_{12} is the only term in (12) which involves the masses of the bodies in any way. Hence the curious conclusion that, when complex stresses are absent, $\dot{n}$ will be independent of both the absolute mass and the mass distribution.

SOME EXAMPLES

1. *Waves in an infinite elastic plate.* The most recent work on this subject[2] affords an instance of equation (1); for while the result as published does not resemble equation (1), it reduces to it identically on setting $\Phi_0(\sigma) = \pi(2k + 1)\sqrt{\dfrac{1 - \sigma}{(1 + \sigma)(1 - 2\sigma)}}$ in which k is any integer, the length L of equation (1) being taken to be the thickness of the plate.

2. *Resonance periods of similar structures.* Let quantities pertaining to the original, full-sized structure be distinguished by the subscript 0; while those referring to the model are without subscripts. Then by (1) and (6)

$$\frac{n_0}{n} = \frac{L}{L_0}\sqrt{\frac{E_0}{E}}\sqrt{\frac{\rho}{\rho_0}} = \sqrt{\frac{S_0}{S}}\sqrt{\frac{m}{m_0}}$$

the first form being preferable when stiffness measurements can not be made; the second when the properties of the material are not known.

3. *Temperature compensation of ordinary tuning fork.* For any case of pure bending or stretching, β can not enter (4); hence $c = 0$, and $\dot{n} = \frac{1}{2}(\alpha + \gamma)$, which agrees with (2). Assuming α negative and γ positive, as is true for steel, compensa-

[2] LAMB, H. Proc. Roy. Soc. **93** (A): 114–128, eq. (80). 1917.

tion requires that their numerical values be made equal. There were some persons who took the trouble to construct a certain tuning fork of invar, in hopes of diminishing its temperature coefficient; as would be seen from the above equation, this only made matters worse.

4. *Shrill tuning fork.* For any case of pure twisting or shearing, such as the very short stubby forks used for producing inaudible notes, α cannot enter (4); $c = -1$, and $\dot{n} = \frac{1}{2}(\beta + \gamma)$.

5. *Telephone diaphragm.* For the case of a thin flat circular disc clamped at the edge, and so approximating a telephone diaphragm, the expression for c which would be obtained from model experiments in accordance with (4), if it were not already available as a result of integration,[3] is $c = \dfrac{2\sigma}{1-\sigma}$. With $\sigma = 0.3$, $c =$ about $\frac{6}{7}$, so that (4) becomes $\dot{n} = 1\frac{3}{4}\alpha - \frac{8}{7}\beta + \frac{1}{2}\gamma$. Complete compensation would require that β be about twice α. (Steel samples have been found, with $\dfrac{\beta}{\alpha}$ considerably greater and also less than 2.) But note from (4) that the α and β terms will enter with opposite signs whenever C is positive. Since C is positive for the disc shape, it appears that the temperature coefficient of a disc will always be small compared with that of a tuning fork of the same material, no matter what that material is.

6. *Spring with distributed mass.* If the mass is uniformly distributed in the direction of the displacement and remains so during the deformation, it may be shown by integration that $n = \sqrt{\dfrac{S}{m}}\left[\dfrac{1}{2\pi}\left(1 + \dfrac{1}{3}\dfrac{m_0}{m}\right)^{-\frac{1}{2}}\right]$. This expression is consistent with (6); $f(\sigma)$ being a constant depending on the ratio of the mass of the spring, m_0, to the attached mass, m.

[3] Rayleigh in his Theory of Sound, vol. I, § 221 a, gives for the disc a formula which, in present notation, may be written $n = \sqrt{\dfrac{LE}{m}}\left[0.833\left(\dfrac{h}{\ }\right)^{\frac{3}{2}}(1-\sigma^2)^{-\frac{1}{2}}\right]$. Here L is the diameter and h the thickness. Thus $\Phi(\sigma) = \text{const.}\,(1-\sigma^2)^{-\frac{1}{2}}$. Differentiating as directed by (4) gives the expression for c. (In footnote 6 of previous paper replace 32π by $\dfrac{32}{3}\pi$.)

7. *Balance wheel of a watch.* The well-known expression $n = \frac{1}{2\pi}\sqrt{\frac{S_t}{I}}$ for the case of a weightless spring acting on a rigid mass of moment of inertia I, may also be written $n = \frac{1}{r}\sqrt{\frac{S_t}{m}}\frac{1}{2\pi}$ in which r is the radius of gyration. This agrees with (8). Differentiating, $\dot{n} = \frac{1}{2}\dot{S}_t - \dot{r}$. For the hair spring (pure bending), (9) becomes $\dot{S}_t = \alpha + 3\gamma$, hence for the balance wheel $\dot{n} = \frac{1}{2}\alpha + \frac{3}{2}\gamma - \dot{r}$. The condition for compensation is therefore that the radius of gyration shall be constrained to vary with temperature at the rate $\dot{r} = \frac{1}{2}(\alpha + 3\gamma)$.

8. *Two springs coupled together.* Let spring 1, strained purely by twisting, be coupled to spring 2, which is strained purely by bending; and let both springs be made of the same material. Then ψ_1 and ϕ_2 are constants, so that $C_1 = -1$, $C_2 = 0$, $C_{12} = 0$; $\therefore K = -\eta$, and (12) becomes $\dot{n} = \frac{1}{2}[(1-\eta)\alpha + \eta\beta + \gamma]$. When the twisted spring is stiffer than the bent spring, the β term predominates, and vice-versa. For springs equally stiff, $\eta = \frac{1}{2}$, $\therefore \dot{n} = \frac{\alpha}{4} + \frac{\beta}{4} + \frac{\gamma}{2}$. For two helical springs, $C_1 = C_2 = -1$, so that $\dot{n} = \frac{1}{2}(\beta + \gamma)$; for two leaf springs or elliptical springs, $C_1 = C_2 = 0$, so that $\dot{n} = \frac{1}{2}(\alpha + \gamma)$. These results, including the above formula for $\dot{n}$ in terms of α, β, γ, and η, and subject to the limitations stated, are true independently of the shapes and mass distributions of the two bodies, as well as of their absolute sizes, masses, and elastic moduli.

CRYSTAL OPTICS.—*Dispersion and other optical properties of carborundum.* H. E. Merwin, Geophysical Laboratory.

Along the edge of a very pale green carborundum crystal two areas, each about 0.5 mm. square, were found which were suitable for measuring the ordinary refractive index. The angles, measured from the base, were 32° 13′ and 34° 15′. The refractive index for the extraordinary ray was found by measurements on the interference figure[1] of a colorless plate 0.675 mm. thick and about 3 mm. square.

[1] See Bauer. M. Neues Jahrb., **2**: 49. 1882–83; also Journ. Wash. Acad. Sci., **4**: 533 and 538. 1914.

The dispersion and birefringence are both much less than those calculated by L. E. Jewell[2] from interference phenomena. The birefringence corresponds closely to Becke's[3] measurement, but the refractive index, ω_{Na}, is less than his rough measurements indicated.

TABLE 1

INDICES OF REFRACTION OF CARBONRUNDUM

λ	ω	ϵ
$\mu\mu$		
755	2.616	2.654
745	2.618	2.656
726	2.622	2.660
700	2.627	2.666
671	2.633	2.673
589	2.654	2.697
535	2.675	2.721
486	2.700	2.749
468	2.713	2.763
434	2.741	2.794
422	2.753	2.808
416	2.757	2.812

Microscopical study of several samples of granular carborundum has revealed no definite variations in the refractive index for red light, even in grains of different color. Coarse material which is very black may be, when powdered—grains a few hundredths of a millimeter in diameter—fairly transparent. Bluish grains are notably pleochroic, some from light blue to dark blue, some from olive green to greenish blue. The ω is the more strongly absorbed. Coarse black crystals intimately associated with graphite appear to contain small amounts of material which give small grains a grayish to bluish color by transmitted light, but this material, in all the grains so far observed, has been submicroscopic in size.

The results for ω in table 1 were obtained as averages from the two prisms. The observed values for one prism were 0.003–0.005 higher than for the other. But inasmuch as one face of

[2] Quoted by TONE, in Mineral Industry, **16**: 153. 1907.
[3] Zeitschr. Kryst., **24**: 524. 1895.

each prism showed curvature of 5′ the differences should be regarded as observational. The difference[4] $\epsilon-\omega$ is probably not in error more than ± 0.001.

A recent notice of a study of the physical properties of carborundum by O. Weigel has been published,[5] but no details are available.

MINERALOGY.—*The nomenclature and classification of the native element minerals.* EDGAR T. WHERRY,[1] National Museum.

In many respects it would be difficult to improve upon the nomenclature and classification of native elements worked out in Dana's System of Mineralogy, yet with the advance of scientific knowledge new points of view are certain to arise and newly discovered species to demand place in any scheme, so that changes must be introduced. A few suggestions in this direction are here put forward, for discussion, criticism, or whatever fate they may seem to readers to deserve.

NOMENCLATURE

The names adopted by Dana are as a rule satisfactory, but wherever considerations of simplicity, consistency, and clearness suggest the desirability of changes from his usage, there should be no hesitation about introducing others.

When an element is known to occur in nature in but one form, no name different from that used for it in chemistry is needed; but several elements show polymorphous forms, and these have heretofore been distinguished by adding either: a suffix, as in sulfur and sulfur*ite;* a prefix, as in palladium and *allo*palladium; Greek letters as prefixes, as in α-sulfur and β-sulfur; or adjectives, as in *yellow* phosphorus and *monoclinic* selenium. The last method, using crystallographic adjectives, is preferable, because it can be employed alike in all cases, and its systematic introduction into mineralogical nomenclature is therefore recommended.

[4] The value for the D-line was checked on a thinner plate and, roughly for lithium light, on grains in immersion liquids.

[5] WEIGEL, O. Chem. Abstr., 11: 1066. 1917.

[1] Transferred August 16th to the Bureau of Chemistry.

Many minerals consist of isomorphous mixtures of two or more elements. Two different methods of deriving names for these have been used in the past: first, by combining the names of the elements present, as selentellurium for selenium-bearing tellurium, platiniridium for platinum-bearing iridium, and nickeliron for nickel-bearing iron; and second, by introducing arbitrary or special terms, as volcanite for selenium-bearing sulfur, sisserskite for iridium-bearing osmium, and porpezite for palladium-bearing gold. As one element is almost invariably greatly in excess over the others, these should be regarded as varieties, rather than elevated to the rank of species. It is, further, believed to be highly desirable that species and varieties be distinguished by the terminology applied to them. As arbitrary or special names, including in this case the names of chemical elements, are generally accepted as appropriate for species, it is thought that their application to varieties should be discouraged, and such names as volcanite, sisserskite, and porpezite be discarded.

The use of chemical prefixes with species names in general is also objectionable because of the resulting inconsistencies and ambiguities, as emphasized by Prof. A. F. Rogers;[2] to this the native elements are no exception. For example, the mineral termed allemontite by Haidinger in 1845, a variety of arsenic containing a small amount of isomorphous antimony, has been called antimonarsenic by some mineralogists, and arsenantimony by others. When two diametrically opposed terms are thus applied to a single substance, it is evident that neither can be regarded as clearly expressing its nature, or accepted to the exclusion of others. Many other minerals, as amalgam, iridosmine, awaruite, etc., show similar confusion in their nomenclature.

To simplify matters and to make the terms as unambiguous as possible, the plan recommended by Professor Rogers in the paper cited is favored: that all varieties due to isomorphism be named by means of adjectives, formed by adding the suffix *iferous* to the names of the elements present in smaller amounts (the names being put in the Latin form when necessary for euphony).

[2] Proc. Am. Phil. Soc., **52**: 610. 1913.

CLASSIFICATION

In Dana's System the native elements are first split up into three divisions, non-metals, semi-metals, and metals. The first two divisions, however, show no pronounced differences, and various inconsistencies arise in apportioning the elements between them. For instance, graphite, which is classed as a non-metal, has a more metallic luster and is a better conductor of electricity than arsenic, which is classed as a semi-metal. Selenium is regarded as a non-metal when monoclinic, and as a semi-metal when rhombohedral; and the same would have to be done with sulfur, arsenic, and antimony, were all of their forms included, for these three crystallize in one or more forms with so-called non-metallic, and others with so-called semi-metallic properties. But the illogical character of this arrangement, which assumes that the element changes its fundamental nature on appearing in an unusual crystallized condition, is evident. The distinction between the non- and semi-metals appears, then, to be rather artificial, and both convenience and accuracy suggest that it be abandoned.

The major divisions are in turn subdivided into groups. Throughout the greater part of Dana's System, the groups are composed of minerals of close chemical and crystallographic relationships. Among the elements, however, this arrangement is to some extent departed from, resulting in the establishment of a "carbon group," in which crystallographic similarity is lacking, and a "platinum group," which includes two types of crystallization. As no good reason for this departure appears to exist, it is recommended that these groups be placed on a crystallographic basis. The carbon group then yields an isometric diamond group, into which several recently discovered non-metallic elements fall, and a hexagonal-trigonal graphite group, which may for simplicity be united with the crystallographically identical arsenic group; in graphite $c = 1.386$, which lies between the value for arsenic, 1.401, and that for antimony, 1.324; all three elements have basal cleavage.

Similarly, the platinum group may be split into an isometric and a hexagonal-trigonal group, while tin, which crystallizes in

a still different system, the tetragonal, is assigned to a group by itself.

In listing groups it is thought best to give those of the highest crystallographic symmetry first place, and to arrange the others in the order of decrease in symmetry.

A table of native elements based on the above recommendations follows. Its criticism by anyone interested in the systematic arrangement of mineralogic data will be welcomed.

NOTES ON THE TABLE

The first column includes the names of the species and varieties worked out according to the principles above outlined and recommended for adoption. The composition of each species and variety is given in the second column, isomorphous replacement being represented by a comma, and the element present in largest amount in each case being placed first.

Column 3 contains reasons for the names or arrangements adopted, synonyms (in quotations), and references for the minerals not listed by Dana in either the System of Mineralogy (1892) or the three Appendixes (1899, 1909, 1915).

NATIVE ELEMENT MINERALS. The chemical elements occurring in nature in the free state.

NON-METALS (INCLUDING "SEMI-METALS")		Combined for simplicity.
DIAMOND GROUP. ISOMETRIC		New; includes all non-metals and semi-metals with isometric crystallization, arranged in order of the periodic system.
Diamond (isometric carbon)	C	The retention of the arbitrary name diamond is an exception to the rule for naming polymorphs, but is justified by usage.
Massive	C	"Bort."
Black massive	C	"Carbonado."
Phosphorus, isometric	P	"Yellow phosphorus," "β-phosphorus." Meteoritic; very doubtful.
Arsenic, isometric	As	"Yellow arsenic." Occurrence in nature reported by Vernadskii, *Ōpuit Opisatel'noi Mineralogii* (Descriptive Mineralogy) **1**, 1908; *Centr. Min. Geol.*, **1912**: 762. (Not in Dana.)
Tantalum, columbiferous	Ta, Cb	

GRAPHITE GROUP. HEXAGONAL-TRIGONAL......................	New; a combination of graphite with Dana's tellurium-arsenic group, arranged in order of the periodic system.
Graphite (trigonal carbon)...C	Name retained for the same reason as that of diamond; "Cliftonite" is a meteoritic paramorph of graphite after diamond.
Arsenic, trigonal............As	
Antimoniferous.........As, Sb	"Allemontite" (Dana No. 9). Classed as a species by Dana, but there is no evidence that it is anything but a variety of arsenic containing a variable amount of isomorphous antimony.
Antimony...................Sb	
Arseniferous............Sb, As	
Bismuth....................Bi	
Tellurium, trigonal..........Te	
Seleniferous.............Te, Se	"Selentellurium" (Dana No. 6). Classed as a species by Dana, but there is no evidence that it is anything but a variety of tellurium containing a variable amount of isomorphous selenium. This selenium is present in a trigonal form, which has not yet been discovered to exist independently in nature, but has been produced artificially.
ORTHORHOMBIC-SULFUR GROUP..	The "Sulphur group" of Dana.
Sulfur, orthorhombic........S	The spelling of this name with *f* instead of *ph* is justified by history and usage and has been adopted by the American Chemical Society.
Seleniferous.............S, Se	"Selensulphur" (Dana No. 4), "volcanite." Classed as a species by Dana, but there is no definite evidence that it is anything but a variety of sulfur containing a variable amount of isomorphous selenium; this selenium is present in an orthorhombic form as yet unknown independently.
Telluriferous............S, Te	"Tellursulphur"
MONOLCINIC-SULFUR GROUP......	New; includes all non-metals and semimetals with monoclinic crystallization.
Sulfur, monoclinic...........S	"β-sulfur," "γ-sulfur." β-sulfur is common around volcanoes, but is preservable only as a paramorph of orthorhombic sulfur; γ-sulfur has been reported to occur in nature by Vernadskii, *Opuit*

	Opisatel'noi Mineralogii, **1**, 1908; *Centr. Min. Geol.*, **1912**: 761; and still another form in stable crystals has been described by Suzuki, *Beitr. Min. Japan*, **5**: 231. 1915. (Not in Dana.)
Selenium, monoclinic........Se	"α-selenium"
Arsenic, monoclinic.........As	"Arsenolamprite." Crystallization not certain.
COLLOIDAL GROUP. AMORPHOUS.	New; includes all non-metals and semimetals occurring in the amorphous state.
Carbon, amorphous..........C	The coloring matter of black sediments.
Silicon, dispersoidal.........Si	Suggested to be the cause of the color of smoky quartz, though without statement of evidence, by Königsberger and Müller, *Centr. Min. Geol.*, **1906**: 73, note. (Not in Dana.)
Phosphorus, amorphous.....P	Occurrence in nature reported by Vernadskii, *Opuit Opisatel'noi·Mineralogii*, **1**, 1908; *Centr. Min. Geol.*, **1912**: 762. (Not in Dana.)
Sulfur, amorphous..........S	"Sulfurite." A precipitate in sulfur-spring water; also a volcanic product. (Not in Dana.)
Selenium, amorphous........Se	Occurrence in nature pointed out by Zambonini, *Mineralogia Vesuviana*, p. 24, 1910. (Not in Dana.)
Iodine, amorphous..........I	Occurrence in nature reported by Skey in 1877; Vernadskii, *Centr. Min. Geol.*, **1912**: 762. (Not in Dana.)
METALS......................	Includes the native elements of predominantly basic character.
COPPER GROUP. ISOMETRIC....	When the minerals of Dana's "gold group" are arranged according to the periodic system, copper comes first and the group is here named after it.
Copper......................Cu	Wire copper, a variety, is probably a paramorph of crystalline copper after amorphous copper which has been forced through small openings while soft, corresponding to wire silver. (See below.)
Argentiferous...........Cu, Ag	
Mercuriferous...........Cu, Hg	Brush, *Am. Journ. Sci.*, [2], **31**: 354. 1861, throws doubt on the occurrence of this variety.

Ferriferous.............Cu, Fe	
Silver........................Ag	Wire silver, a common variety, is a paramorph of crystalline silver after amorphous silver, which has been forced through small openings while soft. Mügge, *Neues Jahrb. Min. Geol.*, **1913** (II): 1.
Cupriferous.............Ag, Cu	
Auriferous..............Ag, Au	"Küstelite"
Mercuriferous...........Ag, Hg	"Amalgam," in part; "arquerite," "bordosite," "kongsbergite;" included, along with argentiferous mercury, in the species "amalgam" by Dana, but there is no definite evidence that it is anything but a variety of silver containing variable amounts of isomorphous mercury.
Gold..........................Au	Wire gold, a variety, is probably a paramorph of crystalline gold after amorphous gold which has been forced through small openings while soft, corresponding to wire silver. (See above.)
Cupriferous.............Au, Cu	
Argentiferous...........Au, Ag	"Electrum." Given a special name by the ancients, though recognized by them to be only an argentiferous variety of gold.
Mercuriferous...........Au, Hg	Occurrence in nature reported by Schmitz, *Z. deut. geol. Ges.*, **4**: 137. 1852. (Not in Dana.)
Rhodiferous.............Au, Rh	"Rhodite."
Palladiferous...........Au, Pd	"Porpezite."
Iridiferous.............Au, Ir	Occurrence in nature reported by Wöhler, 1834; Vernadskii, *Centr. Min. Geol.*, **1912**, 760; confirmed by Chernik, *Trav. Mus. Acad. Sci. Petrograd*, **6**: 49. 1912. (Not in Dana.)
Platiniferous...........Au, Pt	Occurrence in nature discovered by Chernik, *Trav. Mus. Acad. Sci. Petrograd*, **6**: 49. 1912. (Not in Dana.)
Mercury....................Hg	"Quicksilver." Liquid at ordinary temperatures, but crystallizes at −39°C.
Argentiferous...........Hg, Ag	"Amalgam" in part. Included, along with mercuriferous silver, in the species "amalgam" by Dana, but there is no definite evidence that it is anything but a variety of mercury containing variable amounts of silver, either in solid, isomorphous form, or dissolved, liquid form.

Auriferous..............Hg, Au	"Gold-amalgam" in part. The gold is either in solid, isomorphous form, or dissolved, liquid form.
Lead........................Pb	
IRON GROUP. ISOMETRIC......	When the minerals of Dana's "platinum-iron group" are arranged according to the periodic system, iron comes first, and the group is here named after it.
Iron.............. ....Fe	"Ferrite." Native iron, both meteoritic and terrestrial, may contain isomorphous copper, vanadium, chromium, manganese, cobalt, nickel, ruthenium, palladium, iridium, platinum, and perhaps other metals; but only two of these occur in sufficient amount to be regarded as giving rise to definite varieties.
Nickeliferous............Fe, Ni	"Edmonsonite," "kamacite," "lamprite," "plessite," "taenite." Meteoritic; the varieties are chiefly separated on the basis of structure.
Platiniferous............Fe, Pt	Occurrence in nature reported by Osann, *Ann. Phys. Chem.*, **14**: 329. 1827. (Not in Dana.)
Nickel, ferriferous...........Ni, Fe	"Awaruite," "josephinite," "octibbehite," "souesite." Both meteoritic and terrestrial; the minerals referred to by the synonyms have been regarded as separate species, but there is no definite evidence that they are anything but varieties of nickel containing small, variable, amounts of isomorphous iron.
Palladium, platiniferous.....Pd, Pt	"Native palladium." May also contain small amounts of isomorphous iridium.
Iridium, platiniferous.......Ir, Pt	"Native iridium." Named "iridium" by Dana and others, although analyses cited show the presence of at least 19% of isomorphous platinum and smaller amounts of other metals, especialy copper and palladium; pure iridium is not known to occur in nature.
Platinum, ferriferous........Pt, Fe	"Native platinum." Named platinum by Dana and others, although analyses show the presence of considerable amounts of isomorphous copper, gold, iron, nickel, rhodium, palladium, osmium, and iridium; only two of

	these, iron and iridium, occur in sufficient amount to be regarded as giving rise to definite varieties.
Iridiferous..............Pt, Ir	Included by Dana partly under "iridium" and partly under "platinum."
TRIGONAL-PALLADIUM GROUP.....	New; includes zinc, classed by Dana as a semi-metal, and the trigonal minerals of the platinum-iron group.
Zinc.........................**Zn**	Occurrence in nature doubtful.
Palladium, trigonal..........**Pd**	"Allopalladium." May contain isomorphous silver, gold, and platinum, although none of these occur in sufficient amounts to be regarded as giving rise to definite varieties,
Osmium, iridiferous.........**Os, Ir**	"Dark iridosmine," "sisserskite." Included, along with the following mineral, in the species "iridosmine" by Dana; but there is no definite evidence that it is anything but a variety of trigonal osmium containing variable amounts of iridium and perhaps other metals.
Iridium, osmiferous.........**Ir, Os**	"Light iridosmine," "nevyanskite." Included, along with the preceding variety, in the species "iridosmine" by Dana; but there is no definite evidence that it is anything but a variety of trigonal iridium; may contain isomorphous copper, iron, ruthenium, rhodium, palladium, osmium, and platinum; of these only osmium occurs in sufficient amount to be regarded as giving rise to a definite variety.
TIN GROUP. TETRAGONAL........	New; included by Dana in the gold group but here separated on the basis of different crystallization.
Tin.........................**Sn**	Occurrence in nature never proved beyond doubt, although there is a specimen in the U. S. National Museum from placers in California which has every appearance of being a natural product.
COLLOIDAL GROUP. AMORPHOUS	New; includes all metals occurring in the amorphous state.
Silver, amorphous...........**Ag**	Known to early German miners, but its character was first recognized by Cornu, *Z. Chem. Ind. Kolloide*, **4**: 187. 1909. (Not in Dana.)

Gold, amorphous............**Au**	Occurrence in nature reported by Cornu, *Z. Chem. Ind. Kolloide,* **4**: 187. 1909. (Not in Dana.)
Sodium, dispersoidal........**Na**	First suggested by Elster and Geitel to be the cause of color of blue halite, *Ann. Phys. Chem.*, **62**: 559. 1897; this has been confirmed by ultramicroscopic study and by successful synthetic experiments, as shown especially by Goldstein, *Nature*, **94**: 494. 1914. (Not in Dana.)
Potassium, dispersoidal......**K**	Suggested to be the cause of color of blue sylvite, by analogy with the preceding substance, by Cornu, *Centr. Min. Geol.*, **1907**, 168; this has been confirmed as in the preceding instance. (Not in Dana.)
Calcium, dispersoidal........**Ca**	Suggested to be the cause of color of certain fluorites by Doelter, *Sitzungsb. Akad. Wiss. Wien*, **1906**, 1312. (Not in Dana.)

MINERALOGY.—*The crystal form of spencerite.* T. L. WALKER, Royal Ontario Museum of Mineralogy, Toronto.

The new mineral spencerite—$Zn_3(PO_4)_2 . Zn(OH)_2 . 3H_2O$—was described by the author in 1916.[1] The material then available was obtained from the H. B. mine near Salmo, British Columbia. It is remarkable for its purity but is wholly in the massive form. From an optical examination it was found to be monoclinic and polysynthetically twinned, the twinning plane and composition face being the orthopinacoid. Plates parallel to the best cleavage, accepted as the orthopinacoid, showed an interference figure with the acute bisectrix nearly normal to this cleavage. Such plates when etched yielded etch figures symmetrical about only one plane. From these observations the author concluded that the mineral is monoclinic.

Spencerite occurs along with other oxidized zinc ores, forming the cores of stalactitic growths, the outer zone of which is always calamine. The spencerite being relatively soluble, the periphery of the spencerite core has as a rule been dissolved, leaving a space between the more soluble core and the resistant calamine.

[1] Mineralog. Mag., **18**, p. 76.

Under the circumstances the survival of crystals of the phosphate was hardly to be expected.

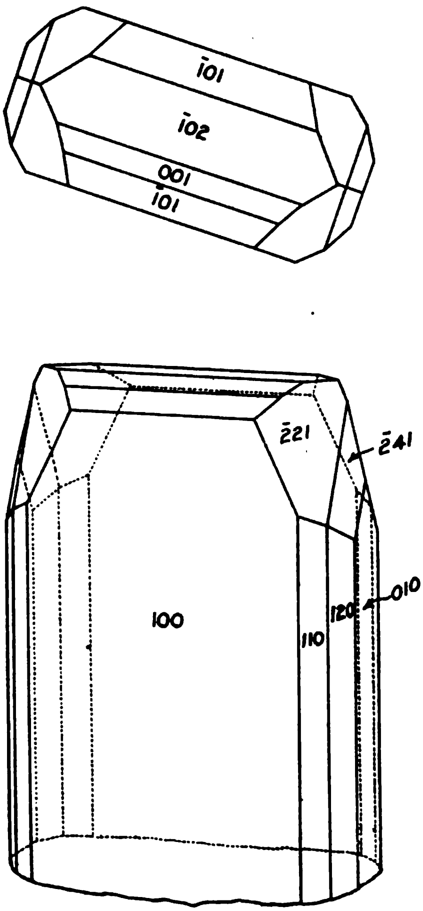

Fig. 1. The crystal is twinned on (100) and as a result of the twinning the forms ($\bar{2}41$) and ($\bar{2}21$) are each represented by four faces, thus giving the crystals a rhombic appearance.

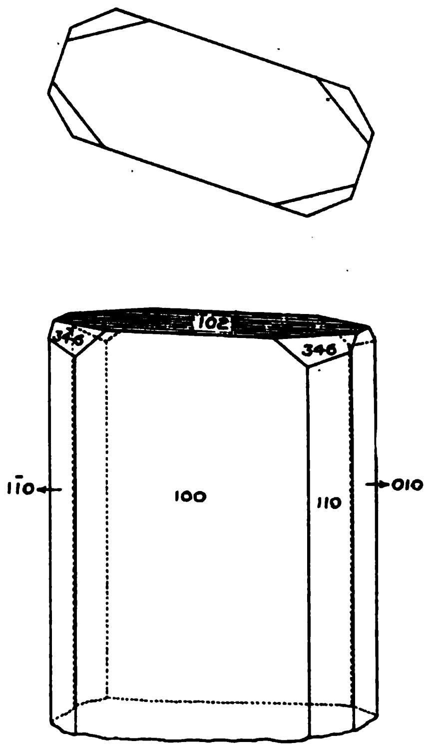

Fig. 2. Crystals of this type exhibit twinning in the duplication of the terminal faces, (346) being represented by four faces while the two faces of ($\bar{1}02$) occur as striations on a large plane nearly coinciding in direction with a rhombic basal pinacoid.

Some specimens of this mineral recently obtained from the original locality contain small druses lined with sharp crystals of spencerite, the preservation of the crystals being apparently due to the cavities having been completely sealed up by calamine.

The crystals are very small, few exceeding 2 or 3 mm. in length. They are tabular in habit and in color, luster, and habit closely resemble small, bright crystals of calamine. The crystals, though small, are admirably suited for accurate measurements. The conclusions regarding the crystal form contained in the original contribution are confirmed, since the mineral is

TABLE 1

FORM	NUMBER OF MEASUREMENTS	ϕ		ρ	
		Measured	Calculated	Measured	Calculated
120	12	29° 34′	29° 32′	90°	90°
230	2	35° 50′	37° 04′	90°	90°
110	11	48° 32′	48° 34′	90°	90°
520	6	71° 07′	70° 34′	90°	90°
010	6	0	0	90°	90°
100	6	90°	90°	90°	90°
001	4	89° 56′	90°	26° 52′	26° 47′
$\bar{1}04$	2	90°	90°	11° 20′	11° 30′
$\bar{1}02$	3	90°	90°	5° 17′	5° 36′
$\bar{3}04$	1	89° 57′	90°	21° 07′	21° 47′
$\bar{1}01$	3	89° 53′	90°	34° 55′	35° 02′
$\bar{2}01$	1	89° 14′	90°	61° 30′	62° 20′
023	1	35° 40′	35° 26′	40° 57′	41° 03′
021	4	13° 30′	13° 21′	65° 32′	65° 25′
121	5	38° 36′	38° 48′	69° 53′	69° 53′
346	3	56° 58′	57° 22′	53° 05′	52° 46′
$\bar{1}11$	2	32° 55′	33° 23′	51° 49′	51° 53′
$\bar{1}21$	6	18° 06′	18° 14′	65° 48′	65° 57′
$\bar{2}21$	4	41° 52′	41° 52′	70° 41′	70° 43′
$\bar{2}41$	4	24° 23′	24° 08′	77° 53′	77° 54′

found to be monoclinic, with polysynthetic twinning on the pinacoid (100).

There are two types of crystals, the first of which is represented in figure 1. The peculiarity of this type is the prominence of the pyramid $\bar{2}21$ with relatively small terminal faces of the orthodiagonal zone. Crystals of the second type are terminated by

what appears to be a large face intersecting the prism edges at 90°. A careful examination shows that this large terminal plane is striated, the faces of the striations belonging to the form ($\bar{1}02$). (See fig. 2.) All the crystals measured are twinned and show faces of the two constituent individuals.

The polar elements derived from the measurements are as follows:

$$p_o = 1.0512; q_o = 0.9501; e = 0.45071; \mu = 63°13'$$

corresponding to the axial ratios,

$$a: b: c :: 1.0125: 1: 1.0643; \beta = 63°13'.$$

In table 1 are indicated the forms observed and the polar angles ϕ and ρ measured and calculated for the elements indicated above. The number of faces observed for each form on the four crystals measured is shown in the second column.

ETHNOLOGY.—*A prehistoric stone mortar from southern Arizona.*[1] J. WALTER FEWKES, Bureau of American Ethnology.

Prehistoric buildings in the Gila Valley differ from those of southern Colorado and New Mexico in materials employed, form, and details in construction and arrangement of sacred and other rooms. There are less pronounced differences in ceramics, implements, and household utensils of the two areas. The acquisition of a fine, characteristic stone mortar from near Casa Grande has led me to describe it and incidentally to refer to a feature in this object not shared with mortars from the true Pueblo area.

A short time ago I obtained from Mr. John Miller, one of my workmen at the Casa Grande ruin in 1907, a stone mortar of more than ordinary interest on account of its artistic character. This object was found 5 miles south of the Picacho reservoir, Arizona, where there are traces of ancient settlements. It is made of a light-colored volcanic stone of circular shape and has a flat base with a cavity or depression on the opposite face. The

[1] Published by permission of the Secretary of the Smithsonian Institution.

remarkable feature is a rattlesnake sculptured in high relief on the margin (fig. 1).

The body of this animal almost completely surrounds the mortar, the anterior end of the body being coiled, and the tail ending in four rattles and a button. The head projects from the coiled part of the body and is flat above, indented with three pits, two of which were intended for eyes. The body is covered with a cross hatching of incised lines representing scales, and the mouth is a horizontal slit. From the top of the nose to the opposite rim the diameter measures 4¼ inches and the depth of the cavity three-fourths of an inch.

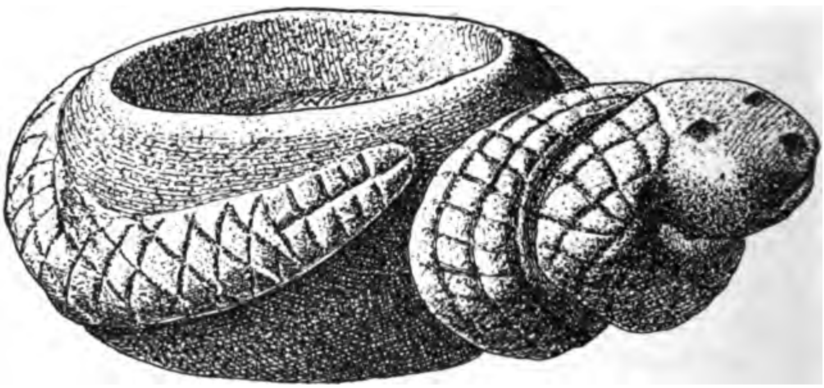

Fig. 1. Snake mortar. Diameter 4½ inches.

The above specimen is now in the Museum of the American Indian, Heye Foundation, New York City.

Mortars made of stone carved in animal forms are not rare in the Gila Valley, although outside of this area they are, so far as known, rarely found in numbers. There are many known examples of mortars of round, oblong shapes, sometimes with prolongations on the larger axes, representing conventionalized organs, but in others the intended form is so realistic that the animal can be roughly identified.

One of the best of these was found in Compound B of the Casa Grande group and figured as an idol in my report[2] on that ruin.

[2] Twenty-eighth Annual Report of the Bureau o' American Ethnology, plate 47.

Others in form of frogs and turtles may be seen in local collections or figured in descriptions of Gila Valley antiquities. I recall two mortars with serpentine bodies cut on their margins, neither of which is as well made as the specimen above described. Mortars from this region in the form of other animals are also known. A mortar from the San Pedro Valley resembling a horned quadruped is figured in my paper on Prehistoric Ruins of the Gila Valley,[3] and there is in the Museum of the University of Arizona a specimen similar to the last mentioned. Mr. Warren K. Moorehead[4] figures a mortar resembling a turtle or some reptile. In all these the depression or cavity of the mortar is situated on the back of the animal, whereas in the snake mortars, the snake surrounds or embraces the mortar.

It will be noticed that these specimens have a depression or cavity which has led to their identification as mortars. In this respect they differ from paint palettes, likewise prehistoric, found in numbers in the Gila region. The stones upon which paint is ordinarily ground among the Pueblos are flat, undecorated slabs, without cavities, or generally only shallow depressions. Similar palettes from the Gila are made with more care and their margins are commonly bands decorated with incised geometrical designs or even, in one or two known instances, with figures of snakes or other animals. They are ordinarily rectangular in form, but other shapes also occur, such as circles and ovals. A figure of one of these tablets or palettes in the shape of a bird was obtained from Pueblo Viejo on the Upper Gila, and published in my account of Two Summers' Work in Pueblo Ruins.[5] A typical hitherto undescribed rectangular paint palette which was plowed up by a farmer on the north side of the Gila, 6 miles from Florence, Arizona, is shown herewith (fig. 2). This is a thin slab of rock with a marginal frame covered with incised crosshatched lines recalling the conventional way of representing scales of a snake. This specimen, like the snake mortar, is

[3] Smithsonian Miscellaneous Collections, Quarterly Review, 5, fig. 75*a*.

[4] The Stone Age in North America, 2, fig. 416.

[5] Twenty-second Annual Report of the Bureau of American Ethnology; also Preliminary Report in Smithsonian Miscellaneous Collections, 1896.

also in the Museum of the American Indian, Heye Foundation. Similar paint palettes with modifications in decorations are widely distributed; those from the mound-builders sometimes bear incised figures of serpents in their surfaces. As a paint palette admits of few variations in form it is not strange that similar shapes occur likewise among Pueblos and mound-builders,[6] and, especially in predynastic times, in Egypt[7] (fig. 3).

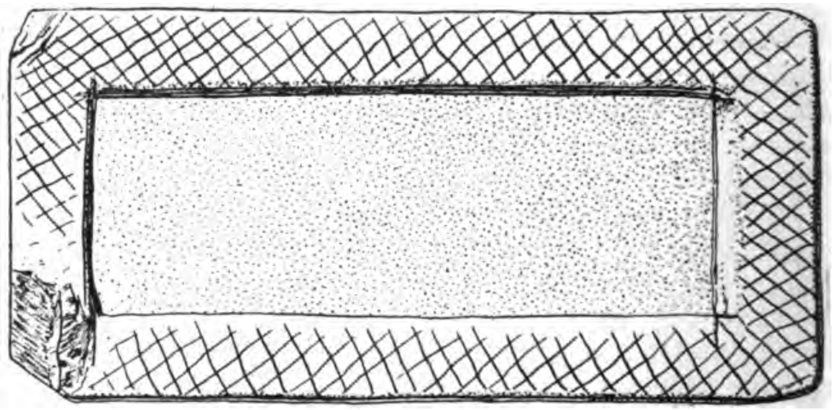

Fig. 2. Paint palette. Size 2¼ by 4½ inches.

Everything used by a primitive people in their ceremonies has, from that fact, a magic power and the stones upon which pigments are ground by the Pueblos partake in a measure of this power. The symbolic figures that decorate paint palettes no doubt increase, in their opinion, the efficacy of the pigment. A similarity in the way these palettes are regarded in the Old and the New World is a good instance of thought convergence.

A few objects of stone supposed to be pestles or paint grinders, possibly used with these pigment palettes, are known from the Gila. One of these from Casa Grande has the form of a "coiled serpent,"[8] a highly suggestive fact taken in connection with a snake-decorated mortar.

[6] Holmes, W. H., *Certain notched or scalloped stone tablets of the mound builders.* Amer. Anthropol., **8**, No. 1, fig. 9. Jan.–March, 1906.

[7] Bates, Oric. *Ancient Egyptian fishing.* Harvard African Studies, No. 1.

[8] Twenty-eighth Annual Report of the Bureau of American Ethnology, pl. 48, fig. 1.

The custom of decorating mortars and paint grinders with animal figures points to Mexican rather than Pueblo customs and kinship. The serpent as an element in sculpture is especially Mexican, although figures of the rattlesnake occur on pipes and stone or shell objects throughout the mound-builders and Pueblo areas; while painting of the same on pottery, and as pictographs ascribed to prehistoric times, are no less frequent. The cult of the Plumed Snake or, as some prefer to call it, the Horned Snake, occurs so constantly in Indian mythology and ritual that this

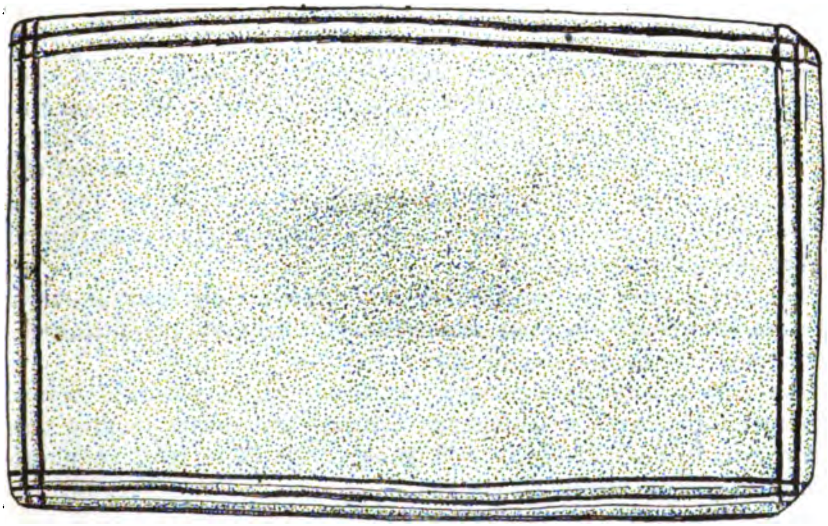

Fig. 3. Egyptian slate palette. Size 3½ by 5½ inches.

being is frequently represented on ceremonial paraphernalia; but there are, so far as I know, few if any mortars of prehistoric Indians of North America with sculptured figures that artistically excel the snake mortar above figured. The snake-entwined mortar is another evidence that the prehistoric culture of the Gila had a close relationship to that of the aborigines of northern Mexico.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

TECHNOLOGY.—*Temperature measurements in Bessemer and open hearth practice.* GEORGE K. BURGESS. Bureau of Standards Technologic Paper No. 91. Pp. 29. 1917.

The problem of temperature measurement and pyrometric control of furnace casting and ingot teeming temperatures is shown, by a series of observations taken in several steel plants, to present no serious difficulties or uncertainties.

For this purpose the most satisfactory type of instrument is one of the optical pyrometers using monochromatic light and permitting observation of streams of metal from a distance.

It is shown that the necessary corrections to the observed optical pyrometer readings for emissivity of metal and oxides to give true temperatures, are sufficiently well known, but there may be uncertainty in the case of liquid slags.

For streams of liquid iron or steel the most probable value of emissivity to take, with a pyrometer using red light of wave length $\lambda = 0.65\ \mu$, is $e = 0.40$, corresponding to a correction of 139° for an observed temperature of 1500°C. The value of e for liquid slags is usually about 0.65 but varies with the composition of the slag. A table of emissivity corrections is included in the text.

It is believed that a continuous, systematic following of the temperature by the methods outlined in the paper would show the possibility of improvements, and give a greater certainty of the production of the desired quality of product. G. K. B.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to scientific papers published in or emanating from Washington. It is requested that authors cooperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

ASTROPHYSICS

ABBOTT, C. G., and ALDRICH, L. B. *On the use of the pyranometer.* Smithsonian Misc. Coll., **66**, No. 11. Pp. 9. 1916.

CLAYTON, H. H. *Effect of short period variations of solar radiation on the earth's atmosphere.* Smithsonian Misc. Coll., **68**, No. 3. Pp. 18. 1917.

COBLENTZ, W. W. *Application of the photoelectric cell as a pyrheliometer.* Phys. Rev., (2) **9**: See 572. 1917.

MERRILL, P. W. *Spectroscopic observations of stars of class Md.* Publ. Astron. Obs. Univ. Michigan, **2**: 45–70. 1916.

MERRILL, P. W. *A spectrum of the P Cygni type.* Publ. Astron. Obs. Univ. Michigan, **2**: 71–75. 1916.

MERRILL, P. W. *Discovery of two bright-line stars of class B.* Publ. Astron. Obs. Univ. Michigan, **2**: 181. 1916.

GEOPHYSICS

BAUER, L. A., and SWANN, W. F. G. *Results of atmospheric-electric observations made aboard the Galilee (1907—1908), and the Carnegie (1909–1916).* Carnegie Institution of Washington, Publication No. 175, 361–447. 1917.

BECKER, G. F. *Mechanics of the Panama Canal slides.* U. S. Geological Survey Professional Paper 98-N. Pp. 253–261. 1916.

JAGGAR, T. A. *Live aa lava at Kilauea.* Journ. Wash. Acad. Sci., **7**: 241–243. 1917.

LITTLEHALES, G. W. *In relation to the extent of knowledge concerning the oceanography of the Pacific.* Proc. National Acad. Sci., **2**: 419–421. 1916.

MARVIN, C. F. *Marine meteorology and the general circulation of the atmosphere.* Proc. National Acad. Sci., **2**: 421–424. 1916.

MERRILL, P. W. *The registration of earthquakes at the Detroit observatory during the years 1914 and 1915.* Publ. Astron. Obs. Univ. Michigan, **2**: 165–177. 1916.

MEUNIER, S. *A theory of terrestrial volcanoes and the geography of the moon.* Journ. Wash. Acad. Sci., **6**: 637–649. 1916.

SWANN, W. F. G. *On the origin of the earth's electric charge.* Phys. Rev., (2) **9**: 555–557. 1917.

TERRESTRIAL MAGNETISM

BAUER, L. A. *Annual report of the Director of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, 1916.* Carnegie Inst. Year Book, **15**: 287–336. 1917.

BAUER, L. A., and FISK, H. W. *On the results of some magnetic observations during the solar eclipse of August 21, 1914.* Journ. Terr. Mag., **21**: 57–86. 1916.

BAUER, L. A., and PETERS, W. J. *Some discussion of the ocean magnetic work, 1905–1916.* Carnegie Institution of Washington, Publication 175, 423–438. 1917.

BAUER, L. A., PETERS, W. J., AULT, J. P., and FLEMING, J. A. *The magnetic work of the Carnegie 1909–1916.* Carnegie Institution of Washington, Publication No. 175, 157–358. 1917.

BAUER, L. A., PETERS, W. J., and FLEMING, J. A. *The magnetic work of the Galilee, 1905–1908.* Carnegie Institution of Washington, Publication No. 175, 1–154. 1917.

HAZARD, D. L. *Activity of the earth's magnetism.* Terr. Mag. Atm. Elec., **22**: 84–86. 1917.

HAZARD, D. L. *Terrestrial Magnetism.* Amer. Year Book, **1916**: 603–604. 1917.

GEODESY

AVERS, H. G., and COWIE, G. D. *Precise leveling from Reno to Las Vegas, Nev., and from Tonopah Junction to Laws, Cal.* U. S. Coast and Geodetic Survey, Special Publication No. 39. Pp. 49. 1916.

JONES, E. L. *Use of mean sea level as the datum for elevations.* U. S. Coast and Geodetic Survey, Special Publication No. 41. Pp. 21. 1917.

GRAVITATION

BOWIE, W. *Investigations of gravity and isostasy.* U. S. Coast and Geodetic Survey, Special Publication No. 40. Pp. 196. 1917.

BRIGGS, L. J. *A new method of measuring the acceleration of gravity at sea.* Proc. National Acad. Sci., **2**: 399–407. 1916.

PHYSICS

AGNEW, P. G., STANNARD, W. H., and FEARING, J. L. *A system of remote control for an electric testing laboratory.* Bureau of Standards Scientific Paper No. 291 (Bull. Bur. Stds., **13**: 581–597). 1916.

BINGHAM, E. C., and JACKSON, R. F. *Standard substances for the calibration of viscometers.* Journ. Wash. Acad. Sci., **7**: 53–55. 1917; Bureau of Standards Scientific Paper No. 298 (Bull. Bur. Stds., **14**: 59–86.) 1917.

BAUER, L. A., and SWANN, W. F. G. *Experiments concerning "magnet-photography."* Phys. Rev., (2) **9**: 563–564. 1917.

BRIGGS, L. J. *The living plant as a physical system.* Journ. Wash. Acad. Sci., **7**: 89–111. 1917.

BROOKS, H. B., and WEAVER, F. C. *A variable self and mutual inductor.* Bureau of Standards Scientific Paper No. 290 (Bull. Bur. Stds., **13**: 569–580.) 1916.

Bureau of Standards. *Testing of clinical thermometers.* Bur. Stds. Circular No. 5, ed. 3. Pp. 20. 1917.

Bureau of Standards. *Fees for electric, magnetic, and photometric testing.* Bur. Stds. Circular No. 6, ed. 7. Pp. 30. 1916. (Contains information concerning the range and the precision of the usual tests and the conditions governing the acceptance of material for test.)

Bureau of Standards. *Electric units and standards.* Bur. Stds. Circular No. 60. Pp. 68. 1916.

Burrows, C. W. *The correlation of the mechanical and magnetic properties of steel.* Bureau of Standards Scientific Paper No. 272 (Bull. Bur. Stds., **15**: 173–210). 1916.

Burrows, C. W., and Sanford, R. L. *An experimental study of the Fahy permeameter.* Bureau of Standards Scientific Paper No. 306 (Bull. Bur. Stds., **14**: 267–300). 1917.

Coblentz, W. W. *The exudation of ice from the stems of plants.* The Scientific Monthly, **2**: 334–349. 1916.

Coblentz, W. W. *Some new designs of radiometers.* Journ. Wash. Acad. Sci., **6**: 473–475. 1916.

Coblentz, W. W. *Characteristics and comparative sensitiveness of various types of radiometers.* Journ. Wash. Acad. Sci., **7**: 164–165. 1917.

Coblentz, W. W. *The emissivity of straight and helical filaments of tungsten.* Bureau of Standards Scientific Paper No. 300 (Bull. Bur. Stds., **14**: 115–131). 1917; Elec. World, **69**: 329. 1917.

Coblentz, W. W., and Emerson, W. B. *Determinations of luminous efficiency and the mechanical equivalent of light.* Phys. Rev., (2) **9**: 569–570. 1917.

Coblentz, W. W., and Emerson, W. B. *Luminous radiation from a black body and the mechanical equivalent of light.* Bureau of Standards Scientific Paper No. 305 (Bull. Bur. Stds., **14**: 255–256). 1917.

Coblentz, W. W., and Emerson, W. B. *The relative sensibility of the average eye to light of different colors, and some practical applications to radiation problems.* Phys. Rev., (2) **9**: 87–88. 1917; Bureau of Standards Scientific Paper No. 303 (Bull. Bur. Stds., **14**: 157–236). 1917.

Coblentz, W. W., and Emerson, W. B. *Reflecting power of tungsten and stellite.* Bureau of Standards Scientific Paper No. 308 (Bull. Bur. Stds., **14**: 307–316). 1917.

Coblentz, W. W., and Emerson, W. B. *Glasses for protecting the eyes from injurious radiations.* Bureau of Standards Technologic Paper No. 93. Pp. 14. 1917.

Crittenden, E. C., and Richtmyer, F. K. *An "average eye" for heterochromatic photometry, and a comparison of a flicker and an equality of brightness photometer.* Trans. Soc. Illum. Eng., **11**: 331–356. 1916; Bureau of Standards Scientific Paper No. 299 (Bull. Bur. Stds., **14**: 87–113). 1917. (Slightly revised form of the 1916 paper.)

Dellinger, J. H. *Calculation of Planck's constant C_2.* Bureau of Standards Scientific Paper No. 387 (Bull. Bur. Stds., **13**: 535–546). 1916.

Dellinger, J. H. *The international system of electric and magnetic units.* Bureau of Standards Scientific Paper No. 292 (Bull. Bur. Stds., **13**: 599–631). 1916.

Dellinger, J. H. *Rationalization of the magnetic units.* Elec. World., **68**: 810. 1916; Electrician, **78**: 290. 1916.

DORSEY, N. E. *Luminescence measurements.* Journ. Wash. Acad. Sci., **7**: 1–6. 1917.

EDWARDS, J. D. *A specific gravity balance for gases.* Gas Record, **10**: 401–405. 1916; Bureau of Standards Technologic Paper No. 89. Pp. 20. 1917.

EDWARDS, J. D. *The effusion method of determining gas density.* Met. Chem. Engin., **16**: 518–524. 1917; Gas Age, **39**: 581–587. 1917; Bureau of Standards Technologic Paper No. 94. Pp. 30. 1917.

FOOTE, P. D. *A visibility equation derived from the Ives and Kingsbury new luminosity equation.* Journ. Wash. Acad. Sci., **7**: 317–318. 1917.

HERSCHEL, W. H. *Discussion of paper by H. C. Hayes and G. W. Lewis, The measurement of viscosity and a new form of viscosimeter.* Journ. Amer. Soc. Mech. Eng., **38**: 630. 1916.

HERSEY, M. D. *The theory of the torsion and the rolling ball viscosimeters, and their use in measuring the effect of pressure on viscosity.* Journ. Wash. Acad. Sci., **6**: 525–530. 1916.

HERSEY, M. D. *The measurement of viscosity.* Journ. Amer. Soc. Mech. Eng., **38**: 1002–1003. 1916.

HERSEY, M. D. *The theory of the stiffness of elastic systems.* Journ. Wash. Acad. Sci., **6**: 569–575. 1916.

HERSEY, M. D. *Note on an integrating device.* Journ. Wash. Acad. Sci., **6**: 617–620. 1916.

HERSEY, M. D. *Note on a relation connecting the derivatives of physical quantities.* Journ. Wash. Acad. Sci., **6**: 620–629. 1916.

JACKSON, R. F. *The saccharimetric normal weight and specific rotation of dextrose.* Bureau of Standards Scientific Paper No. 293 (Bull. Bur. Stds., **13**: 633–635). 1916.

MERRILL, P. W. *Wave-lengths of the stronger lines in the helium spectrum.* Bureau of Standards Scientific Paper No. 302 (Bull. Bur. Stds., **14**: 159–166.) 1917.

MUELLER, E. F. *Wheatstone bridges and accessory apparatus for resistance thermometry.* Bureau of Standards Scientific Paper No. 288 (Bull. Bur. Stds., **13**: 547–561). 1916.

NUTTING, P. G. *Criteria for gray radiation.* Journ. Wash. Acad. Sci., **6**: 476–478. 1916.

OSBORNE, N. S. *An aneroid calorimeter for specific and latent heats.* Bureau of Standards Scientific Paper No. 301 (Bull. Bur. Stds., **14**: 133–157). 1917.

PRIEST, I. G. *A proposed method for the photometry of lights of different colors.—II.* Phys. Rev., (2) **9**: 341–345. 1917.

PRIEST, I. G., and PETERS, C. G. *Measurement and specification of the physical factors which determine the saturation of certain tints of yellow.* Bureau of Standards Technologic Paper No. 92. Pp. 11. 1917.

RICHTMYER, F. K., and CRITTENDEN, E. C. *The precision of photometric measurements.* Phys. Rev., (2) **9**: 95–96. 1917.

ROESER, H. M. *Calculation of the constants of Planck's radiation equation: An extension of the theory of least squares.* Bureau of Standards Scientific Paper No. 304 (Bull. Bur. Stds., **14**: 237–253). 1917.

ROESER, H. M. *Note on the determination by judgment of the constants of linear empirical formulas.* Phys. Rev., (2) **9**: 80–83. 1917.

Rosa, E. B., and Vinal, G. W. *The silver voltameter as an international standard for the measurement of electric current.* Proc. National Acad. Sci., **3**: 59–64. 1917.

Sanford, R. L. *The determination of the degree of uniformity of bars for magnetic standards.* Bureau of Standards Scientific Paper No. 295 (Bull. Bur. Stds., **14**: 1–14). 1916.

Silsbee, F. B. *A note on electrical conduction in metals at low temperature.* Journ. Wash. Acad. Sci., **6**: 597–602. 1916; Bureau of Standards Scientific Paper No. 307 (Bull. Bur. Stds., **14**: 301–306.) 1917.

Stillman, M. H. *The damping of waves and other disturbances in mercury.* Bureau of Standards Scientific Paper No. 289 (Bull. Bur. Stds., **13**: 563–568). 1916.

Stratton, S. W. *Annual report of the Director of the Bureau of Standards for the fiscal year ending June 30, 1916.* Pp. 165. 1916.

Swann, W. F. G., and Mauchly, S. J. *On the conduction of electricity through an ionized gas, more particularly in its relation to Bronson resistances.* Terr. Mag. Atm. Elec., **22**: 1–21. 1917.

Weibel, E. *A study of electromagnet moving coil galvanometers for use in alternating current measurements.* Bureau of Standards Scientific Paper No. 297 (Bull. Bur. Stds., **14**: 23–58). 1917.

Wilhelm, R. M. *The freezing point of mercury.* Bureau of Standards Scientific Paper No. 294 (Bull. Bur. Stds., **13**: 655–661). 1916.

Woodward, R. W., and Harrison, T. R. *Note on the thermocouple nichrome constantan.* Met. Chem. Eng., p. 647. June 1, 1917.

Wright, F. E. *Recent improvements in the petrographic microscope.* Journ. Wash. Acad. Sci., **6**: 465–472. 1916.

CHEMISTRY

v. Bichowsky, F. R. *The electrometric titration of zinc with ferrocyanide.* Journ. Wash. Acad. Sci., **7**: 141–143. 1917.

Clark, W. M., and Lubs, H. A. *The colorimetric determination of the hydrogen-ion concentration of bacteriological culture media.* Journ. Wash. Acad. Sci., **6**: 483–489. 1916.

Ferguson, J. B. *The equilibrium between carbon monoxide, carbon dioxide, sulfur dioxide, and free sulfur.* Proc. National Acad. Sci., **3**: 371–374. 1917.

Lubs, H. A., and Clark, W. M. *A note on the sulphonephthaleins as indicators for the colorimetric determination of hydrogen-ion concentration.* Journ. Wash. Acad. Sci., **6**: 481–483. 1916.

Morey, G. W. *A convenient form of autoclave.* Journ. Wash. Acad. Sci., **7**: 205–208. 1917.

Rawdon, H. S. *Note on the occurrence and significance of twinned crystals in electrolytic copper.* Amer. Inst. Metals, vol. 10. 1916.

Sosman, R. B. *The common refractory oxides.* Journ. Indust. Eng. Chem., **8**: 985–999. 1916.

Sosman, R. B. *Some problems of the oxides of iron.* Journ. Wash. Acad. Sci., **7**: 55–72. 1917.

SOSMAN, R. B., and HOSTETTER, J. C. *The ferrous iron content and magnetic susceptibility of some artificial and natural oxides of iron.* Trans. Amer. Inst. Mining Eng., **53**: 907–931. 1917.

SOSMAN, R. B., and HOSTETTER, J. C. *Zonal growth in hematite, and its bearing on the origin of certain iron ores.* Trans. Amer. Inst. Mining Eng., **53**: 933–943. 1917.

METALLOGRAPHY

BURGESS, G. K. *Temperature measurements in Bessemer and open hearth practice.* Bureau of Standards Technologic Paper No. 91. Pp. 29. 1917.

BURGESS, G. K., and SCOTT, H. *Thermoelectric measurement of the critical ranges of pure iron.* Journ. Wash. Acad. Sci., **6**: 650–651. 1916; Bureau of Standards Scientific Paper No. 296 (Bull. Bur. Stds., **14**: 15–21). 1917.

MERICA, P. D. *The failure of brass.—2. The effect of corrosion on the ductility and strength of brass.* Bureau of Standards Technologic Paper No. 83. Pp. 7. 1916.

MERICA, P. D. *The structure of the coating on tinned sheet copper in relation to a curious case of corrosion of this material.* Bureau of Standards Technologic Paper No. 90. Pp. 18. 1917.

MERICA, P. D., and KARR, C. P. *The failure of brass.—3. Initial stress produced by the burning in of manganese bronze.* Bureau of Standards Technologic Paper No. 84. Pp. 7. 1916.

MERICA, P. D., and WOODWARD, R. W. *The failure of brass.—1. Microstructure and initial stresses in wrought brasses of the type 60 per cent copper and 40 per cent zinc.* Bureau of Standards Technologic Paper No. 82. Pp. 72. 1917.

TECHNOLOGY

AHLBORN, G. H. *Data on electric railway track leakage.* Bureau of Standards Technologic Paper No. 75. Pp. 22. 1916.

BATES, P. H., and KLEIN, A. A. *Properties of the calcium silicates and calcium aluminate occurring in Portland cement.* Bureau of Standards Technologic Paper No. 78. Pp. 34. 1917.

BEARCE, H. W., and PEFFER, E. L. *The density and thermal expansion of American petroleum oils.* Bureau of Standards Technologic Paper No. 77. Pp. 26. 1916.

BLEININGER, A. V., and SCHURECHT, H. G. *The properties of some European plastic fire clays.* Bureau of Standards Technologic Paper No. 79. Pp. 34. 1916.

BLUME, W., HOLLER, H. D., and RAWDON, H. S. *Preliminary studies in the deposition of copper in electroplating baths.* Trans. Amer. Electrochem. Soc., **30**: 159–174. 1916.

BOUGHTON, E. W. *Effect of certain pigments on linseed oil.* Bureau of Standards Technologic Paper No. 71. Pp. 16. 1916.

BOUGHTON, E. W. *Determination of volatile thinner in oil varnish.* Bureau of Standards Technologic Paper No. 76. Pp. 7. 1916.

BUREAU OF STANDARDS. *Report on the tenth annual Conference on Weights and Measures, May 25–28, 1915.* Bur. Stds. Special Publication. Pp. 254. 1916.

BUREAU OF STANDARDS. *United States Government specification for Portland cement.* Bur. Stds. Circular No. 33, ed. 3. Pp. 43. 1917.

BUREAU OF STANDARDS. *National electrical safety code.* Bur. Stds. Circular No. 54, ed. 2. Pp. 323. 1916.

BUREAU OF STANDARDS. *Standards for electric service.* Bur. Stds. Circular No. 56. Pp. 262. 1916.

BUREAU OF STANDARDS. *Specifications and tolerances for weights and measures and weighing and measuring devices.* Bur. Stds. Circular No. 61. Pp. 44. 1916.

BUREAU OF STANDARDS. *Specifications for and methods of testing soaps.* Bur. Stds. Circular No. 62. Pp. 25. 1916.

BUREAU OF STANDARDS. *Specification and tests of the transparency of paper and tracing cloth.* Bur. Stds. Circular No. 63. Pp. 8. 1917.

BUREAU OF STANDARDS. *Rules and regulations for enforcement of lime-barrel act.* Bur. Stds. Circular No. 64. Pp. 70. 1917.

BUREAU OF STANDARDS. *Gas calorimeter tables.* Bur. Stds. Circular No. 65. Pp. 19. 1917.

BUREAU OF STANDARDS. *Standard samples for thermometric fixed points.* Bur. Stds. Circular No. 66. Pp. 13. 1917. (Describes the methods of preparation and the chemical analyses of the metals, tin, zinc, aluminium, and copper, which have been prepared for distribution.)

CAIN, J. R., and RAWDON, H. S. *Report on the investigation of ladle-test steel ingots.* Proc. Amer. Soc. Test. Mater., **16**: 129–144. 1916.

EMLEY, W. E. *The manufacture and properties of sand-lime brick.* Bureau of Standards Technologic Paper No. 85. Pp. 41. 1917.

HERSCHEL, W. H. *Discussion of the report of committee D-4 on road materials.* Proc. Amer. Soc. Test. Mater., **16**: 316. 1916.

HERSCHEL, W. H. *Quantitative test for resistance of lubricating oils to emulsification.* Proc. Amer. Soc. Test. Mater., **16**: 248. 1916.

HERSCHEL, W. H. *Testing of lubricating oils; an address delivered before the Independent Oil Mens Association, Chicago, Oct. 19, 1916.* Oildom, **6**: 590. 1916.

HERSCHEL, W. H. *Design of a water brake.* Power, p. 133. 1916; Engineering News, p. 378. 1916.

HERSCHEL, W. H. *The testing and standardization of lubricating oils.* Oil, Paint, and Drug Reporter, **91**: 14. 1917.

HERSCHEL, W. H. *Notes on speed indicators for airplanes. The Pitot tube.* Aviat. and Aeronaut. Eng., p. 384. 1917.

HERSCHEL, W. H. *Note on speed indicators for airplanes. The Venturi tube.* Aviat. and Aeronaut. Eng., Feb. 15, 1917.

HERSCHEL, W. H. *The resistance of an oil to emulsification.* Bureau of Standards Technologic Paper No. 86. Pp. 37. 1917.

KLEIN, A. A. *The constitution and microstructure of porcelain.* Journ. Wash. Acad. Sci., **6**: 658–660. 1916; Bureau of Standards Technologic Paper No. 80. Pp. 38. 1916.

LEWIS, W. S. *Comparative tests of stitches and seams.* Bureau of Standards Technologic Paper No. 96. Pp. 19. 1917.

McCULLOM, B., and AHLBORN, G. H. *Influence of frequency of alternating or infrequently reversed current on electrolytic corrosion.* Bureau of Standards Technologic Paper No. 72. Pp. 31. 1916.

ROSA, E. B., BROOKS, H. B., MCCULLOM, B., CANADA, W. J., and GLADDING, F. W. *An investigation of cartridge enclosed fuses.* Bureau of Standards Technologic Paper No. 74. Pp. 199. 1916.

SCHLINK, F. J. *Liquid-measuring pumps.* Bureau of Standards Technologic Paper No. 81. Pp. 27. 1916.

SCHLINK, F. J. *A simple and accurate balance for the shop.* Machinery, pp. 413–414, Jan., 1917.

SMITH, W. H. *Recovery of paraffin and paper stock from waste paraffin paper.* Bureau of Standards Technologic Paper No. 87. Pp. 4. 1916.

SMITH, W. H. *Studies on paper pulp.* Bureau of Standards Technologic Paper No. 88. Pp. 13. 1917.

WATERS, C. E. *Further data on the oxidation of automobile cylinder oils.* Bureau of Standards Technologic Paper No. 73. Pp. 20. 1916.

WIG, R. J., PEARSON, J. C., and EMLEY, W. E. *Durability of stucco and plaster construction.* Bureau of Standards Technologic Paper No. 70. Pp. 74. 1917.

WIG, R. J., WILLIAMS, G. M., FINN, A. N., MCCRORY, S. H., BEBB, E. C., and FERGUSON, L. R. *Durability of cement drain tile and concrete in alkali soil.* Bureau of Standards Technologic Paper No. 95. Pp. 94. 1917. (Supersedes Technologic Paper No. 44.)

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 787th meeting was held at the Cosmos Club, March 31, 1917. President BUCKINGHAM in the chair; 36 persons present. The minutes of the 786th meeting were read in abstract and approved.

The following resolution was unanimously adopted:

Resolved: That the Philosophical Society of Washington endorses the movement to extend the use of the metric system and commends the efforts of the American Metric Association to this end.

Mr. FREDERICK BATES and Mr. F. P. PHELPS gave an illustrated paper on *The rotation of the plane of polarization in quartz and iron at high temperatures.*

Curves showing the results of precision measurements for both the natural and the magnetic rotation of the plane of polarization in quartz for a temperature range from 20°C. to 1000°C. were exhibited. Quartz recrystallizes at about 575°C. changing from α to β quartz. The curve for the variation of the natural rotation with the temperature makes a right angle turn at this point and shows evidence of a discontinuity. In contrast to the natural rotation the magnetic rotation shows no change at 575° and has no temperature coefficient. For measuring the rotations a large Weiss, water-cooled electromagnet was used. The furnace was placed between the poles of the magnet and the temperature was obtained by means of a standard thermocouple. Monochromatic light of high intensity was passed through the plate parallel to the magnetic field. Similar curves for the magnetic rotation in films of electrolytic iron and iron oxides were also shown. The results indicate that the optical phenomena disappear at the temperature at which the metal loses its magnetic properties.

Discussion. The paper was discussed by Messrs. WHITE and WRIGHT. Mr. G. K. BURGESS spoke of the possibility of harmonizing results showing the magnetic rotation of films of iron which had become oxidized, by disregarding the oxygen and considering only the iron present.

Mr. F. E. WRIGHT gave an illustrated paper on *The application of polarized light to the study of opaque substances.*

Mr. P. V. WELLS gave an illustrated paper on *A standard of turbidity.* The speaker described briefly the physical properties of turbid media, pointing out that such media are usually in a critical state. Their most striking characteristic is that of scattering light, the effect vary-

ing rapidly with small changes in the other variables, such as temperature or pressure. The factors determining the intensity of the scattered light in the simple case of particles small compared with the wave length of the light were given after the treatment of Rayleigh.

Turbidimetry is chiefly concerned with the measurement of the mass of suspended matter, but, as this is small and its accurate determination difficult, optical measures have frequently been adopted for rapid work. The most definite of these is the intensity of the light scattered in a fixed direction from a layer of turbid medium of definite thickness, illuminated by a parallel incident beam. The logical measure would be the ratio of the scattered and incident intensity. Provisionally, however, the scattered intensity was compared with the intensity of the light diffusely reflected normally from a magnesia surface with the same parallel beam incident at 45°. The magnesia surface was made by depositing the smoke from burning magnesium ribbon upon thin plate glass. The magnesia-glass surface was used because its direction could be determined. It was accurately reproducible. A turbidimeter was described, by means of which these measurements could be made. The readings obtained with doubly distilled water, with turbid liquids, and with air, both pure and vitiated with smoke, were given.

Discussion. Mr. Wright inquired as to the possibility of using the scattering of a beam of polarized light, as measured by the amount of light emerging polarized at right angles to the plane of the entering beam, as an indication of turbidity. Mr. Wells stated that such effects would vary with the size of the suspended particles. Mr. Merwin inquired as to the distribution of the light scattered from the magnesia reference plate. Mr. Wells stated that it had not been measured, but that it probably followed Lambert's law closely. Mr. Bates spoke of the difficulty of producing a perfectly clear fluid, with especial reference to some attempts to remove all suspended particles from oil.

The 788th meeting was held at the Cosmos Club, April 19, 1917. President Buckingham in the chair; 85 persons present.

The entire evening was devoted to hearing an address by Dr. Irving Langmuir on *The constitution of liquids.* (No abstract.) A paper dealing with the subject matter presented will be found in the Proc. National Acad. Sci., **3**: 251–257. 1917.

Discussion. The paper was discussed by Messrs. Sparrow, Buckingham, Swann, and Hersey, and by Messrs. T. C. Mendenhall and R. A. Millikan with especial reference to the questionable but persistent idea of a spherical atom.

The 789th meeting was held at the Cosmos Club, April 28, 1917. Vice President Humphreys in the chair; 39 persons present. The minutes of the 787th and 788th meetings were read in abstract and approved.

The Secretary read the call for the first meeting of the Society and the list of charter members.

Mr. William H. Dall delivered an address on *The origin and early days of the Philosophical Society of Washington*. The address will probably be published in full in this Journal at a later date.

The Secretary read a letter from Mr. G. K. Gilbert, the second oldest member of the Society, conveying his best wishes and expressing regret that it was impossible for him to be present at the meeting.

Mr. F. W. Clarke delivered an address on *The development of scientific societies in Washington*.

Interesting reminiscences of the early days of the society were offered by Messrs. Howard, Farquhar, Wead, and Bauer.

The 790th meeting was held at the Cosmos Club, May 12, 1917 President Buckingham in the chair; 28 persons present. The minutes of the 789th meeting were read in abstract and approved.

Messrs. I. G. Priest and C. G. Peters gave an illustrated paper on *An interferential method for measuring the expansion of very small samples*. This paper describes a method requiring as a sample only *one* small pin about 5 mm. in diameter by 10 mm. long, or even of smaller dimensions. Briefly the outline of the method is as follow:

1. One of a pair of nearly (but not quite) parallel interferometer mirrors is supported at one point by the sample and at two other points by a standard substance of known expansivity.

2. Any difference in the expansivity of the sample and the standard causes the interference fringes to change their *widths* with changing temperature. This change in width is measured, and from it the relative expansion is computed.

Noteworthy advantages of this method over the Fizeau-Pulfrich method are:

1. Smallness of sample required.

2. Elimination of the difficulty of obtaining the interference fringe data. It is not necessary to count the passage of fringes during the temperature change nor to make measurements on fringes of more than one wave length.

3. The very troublesome correction for change in the refractive index of air with temperature is eliminated.

It is expected that a fuller description of this method will appear later as a Scientific Paper of the Bureau of Standards.

Discussion. The paper was discussed by Messrs. Buckingham and Humphreys.

By invitation Mr. J. D. Edwards gave an illustrated paper on *The rapid determination of gas density*.

Because of their importance in connection with orifice meter measurements and other technical and scientific problems, methods for the rapid determination of gas density have been investigated at the Bureau of Standards.

The effusion method which has been widely used for this purpose has been shown to be unreliable, errors of over 10 per cent not being unusual in practice. A study of the theory of the effusion process has revealed the main sources of error in this method. The effusion method under the most favorable conditions can probably not be relied on to better than 1 or 2 per cent.

In order to secure precise results a specific gravity balance employing an indirect weighing method was developed; this enables one to secure results accurate to about 0.2 per cent. This apparatus is convenient to use, may be made portable, and requires no preliminary calibration.

Discussion. The paper was discussed by Messrs. PRIEST, HERSEY, SWEET, BUCKINGHAM, and HUMPHREYS.

Informal communications: Mr. BUCKINGHAM outlined a theory accounting for the errors in the effusion method of determining gas densities.

Mr. C. A. BRIGGS exhibited two combination time and percussion caps for shrapnel shells of types now in use on the Russian battle front.

Mr. H. F. STIMSON exhibited a 2-stage mercury vapor condensation pump for operating between about 4 cm. and 0.0004 mm. of mercury. The low pressure stage is built with a long nozzle of the De Laval type and the high pressure with a short nozzle. In each nozzle the ratio of the higher to the lower pressure is maintained above the critical value of about 2, and the velocity of the vapor in the nozzle is greater than the velocity of sound.

DONALD H. SWEET, *Secretary.*

REPRINT OF HEREDITY LECTURES

A series of three public lectures by Prof. H. S. Jennings, Dr. Oscar Riddle, and Prof. W. E. Castle, dealing with the subject of heredity, was given under the auspices of the Washington Academy of Sciences during March and April, 1917. In view of the wide-spread interest in the lectures, and in response to numerous requests, the Academy has reprinted in collected form a limited edition of the lectures as published in the JOURNAL.

Copies of the brochure, substantially bound in flexible cloth covers, may be purchased of the Treasurer, Mr. William Bowie, Coast and Geodetic Survey, Washington, D. C., at fifty cents each (postage included).

CONTENTS

Original Papers

Page

Physics.—Note on the vibration frequencies of elastic systems. M. D. Hersey 437

Crystal Optics.—Dispersion and other optical properties of carborundum. H. E. Merwin........ 445

Mineralogy.—The nomenclature and classification of the native element minerals. Edgar T. Wherry........ 447

Mineralogy.—The crystal form of spencerite. T. L. Walker........ 450

Ethnology.—A prehistoric stone mortar from southern Arizona. J. Walter Fewkes........ 459

Abstracts

Technology........ 464

References

Astrophysics........ 465
Geophysics........ 465
Terrestrial Magnetism........ 466
Geodesy........ 466
Gravitation........ 469
Physics........ 469
Chemistry........ 469
Metallography........ 470
Technology........ 470

Proceedings

The Philosophical Society of Washington........ 473

VOL. VII

No. 15

SEPTEMBER 19, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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* Volume I, however, from July 19, 1911, to December 19, 1911, will be sent for $3.00. Special rates are given to members of scientific societies affiliated with the Academy.

THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. VII SEPTEMBER 19, 1917 No. 15

PHYSICS.—*A two-stage mercury vapor pump.* H. F. STIMSON, Bureau of Standards. (Communicated by E. Buckingham.)

A "Condensation Pump" was described by Dr. Irving Langmuir[1] which not only produced the highest vacuum yet obtained with a pump but had a speed of exhaustion (cm.³/sec.) greater than any previously existing high vacuum pump. The pump is exceedingly simple. A stream of mercury vapor from a boiler is sent down from a mouth or nozzle into a water jacketed chamber, entrains the gas coming past the nozzle, and condenses when striking the walls of the chamber, thus preventing flow of mercury vapor back to oppose the oncoming gas. This pump requires for its operation a primary vacuum of a few tenths of a millimeter of mercury pressure.

Conditions sometimes make it necessary or desirable to use as a source of primary vacuum either a water aspirator or some mechanical pump which fails to reach a pressure low enough to accommodate a single stage condensation pump. Two pumps modified by Prof. C. A. Kraus of Clark University to essentially the same form as Dr. Langmuir's later design were seen by the author early in September, 1916, working in series against a primary vacuum of 2 cm. given by a water aspirator. The expediency of using a water aspirator even at times when the vapor pressure of water is high has led to the present further development of the mercury vapor pump.

[1] Jour. Franklin Inst., **182**: 719. 1916; Gen. Elec. Rev., **19**: 1060. 1916.

This problem is different from Langmuir's in requiring in the mercury vapor pump the maintenance of a much larger pressure difference by means of a continuous supply of momentum in a manner analogous to the maintenance of a kite in air by the employment of the momentum of the wind. To sustain this large pressure difference a second stage is desirable, for could such a pressure difference be sustained and high vacuum attained with one stage, either a very large current of vapor would be required or the pump would have to be made so small that its speed would be very low. A second stage, on the contrary, in order to pump all the gas discharged from a pump working on high vacuum, need have only a hundredth the speed of the high vacuum stage or even less.

From dimensional reasoning it follows that whatever supports the pressure must have the same physical dimensions. Pressure has the dimensions of force per unit area and force has the dimensions of mass times velocity divided by time:

$$p = f/l^2 = mv/tl^2.$$

In order to make p large, l^2, the cross sectional area across which the stream of mercury vapor acts, can be made small. It is well known that a gas will flow through an orifice with a limiting velocity, which is the velocity of sound, if the ratio of final to initial pressure of the gas on the two sides of the orifice is less than a certain limiting fraction. This fraction for mercury vapor is about 0.49 and the velocity of sound referred to is that velocity determined by the temperature of the vapor in the orifice where it is adiabatically expanded to this limiting pressure. It appears then that mercury vapor can be expelled through an orifice with the velocity of sound by a boiler pressure a little more than twice the pressure of the supporting vacuum. When the boiler pressure is sufficient the velocity may be increased beyond the velocity of sound, as is done in the steam turbine, by an expanding nozzle, but such an enlargement requires an increased working cross section over which the pressure must be supported, thus limiting the advantage of the increased velocity. The term m/t can be increased by increasing the boiler pressure.

thus increasing the density of the discharged vapor. This dimensional reasoning will enable one to proportion properly the dimensions of the elements of a second or intermediate stage which will support a relatively large pressure.

If both stages are to be operated from the same boiler, as is extremely desirable, some change has to be made in the design of the high vacuum unit. On account of the increased boiler pressure a constriction will be necessary to cut down the flow of mercury vapor to a sufficiently low value. This can be most effectively accomplished by using a long DeLaval nozzle which will simultaneously introduce the advantages of reduction of pressure and increase of velocity.

These principles have been considered in the construction of pumps indicated in figure 1. Sample dimensions will be given to indicate working sizes, although the size will in most cases depend on the speed desired. The pump in question, including its boiler, was constructed entirely of Pyrex glass which is well adapted to this use and can be rapidly manipulated. The boiler was made of a half liter Erlenmeyer flask with slightly rounded bottom.

In the intermediate stage is a short slightly expanding nozzle

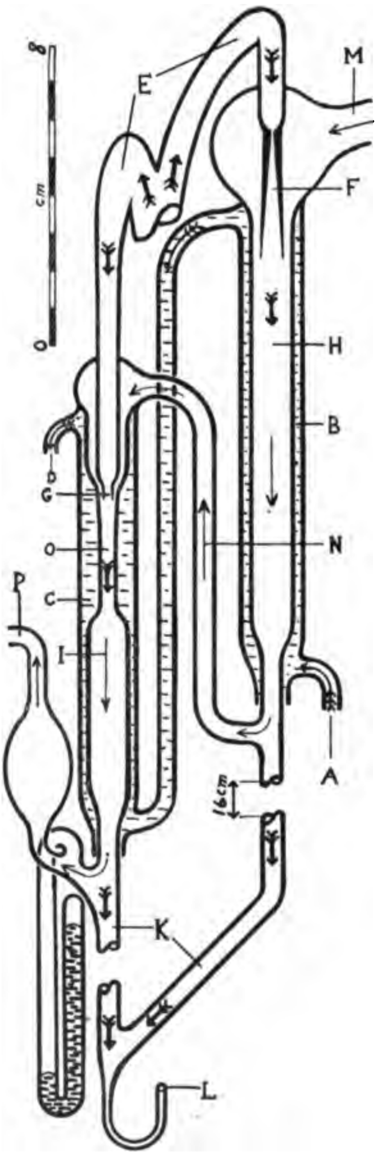

Fig. 1. Two-stage pump.

G, 3 mm. long with a throat 1.8 mm. in diameter, which sends the mercury vapor through a tube O, 3.5 mm. diameter, across which is supported the pressure from a water aspirator used as a fore pump. Care must be taken to leave sufficient clearance around the end of the nozzle G, and the tube O has been slightly tapered leaving a clearance of 0.7 mm., which seems to be sufficient to prevent condensed mercury vapor from collecting to make a seal. It appears that the size of this unit cannot be reduced below a certain limit determined by the surface tension of mercury. The pressure of the vapor in the boiler and feed tubes, E, has been raised to as high as 20 to 25 cm. of mercury, as is indicated while the pump is in action by the height of the mercury columns in tubes K. In the high vacuum stage a DeLaval nozzle, F, with a throat 0.7 mm. in diameter has been used expanding by about a ten to one taper to a diameter of 5 mm. discharging into a tube nearly a centimeter in diameter.

The operation of the pump is as follows. Cooling water entering at tube A flows up through the water jacket B above the lower end of nozzle F, up through the water jacket C above nozzle G, and out tube D. Mercury vapor from the boiler entering through tubes E flows through the nozzles F and G, is liquefied in the condensation chambers H and I, falls into the tubes K, and returns to the boiler through tube L. Gas from a vessel to be exhausted enters at M, flows past nozzle F, is compressed by the jet of mercury vapor in the condensation chamber H, and flows up through tube N to the intermediate pump. From here it flows past the nozzle G and is compressed through O in the chamber I to a pressure measured by the attached manometer, then out by tube P to the water aspirator.

Tests of the pump described above indicate a speed, when working against a primary pressure of 4 cm., of about 250 $cm.^3$ per sec. when speed is defined[2] as

$$S = V/t \log p_1/p_2$$

where S is speed, V is volume, t is time, p_1 and p_2 are initial and final pressures. The pump gives a limit of pressure of non-

[2] GAEDE. Ann. d. Physik, (5) 41: 365. 1913.

condensable gases very much less than a ten-thousandth of a millimeter of mercury as was shown on a MacLeod gage, which was the only low pressure measuring device available.

On account of questions that have been raised from time to time, which threw doubt on the assumption that the vapor flows through the intermediate pump with a velocity comparable with the velocity of sound, verificative experiments were made. A temporary rubber connection with pinch cock on the lower end of the tube K below the intermediate pump allowed the liquefied mercury to be caught and measured, thus giving the term m/t in the dimensional equation. The pressure difference supported by the pump was observed in the manometer arms K and the cross-section of the tube O is known. Computations of velocity from the dimensional equation give a value within a few per cent of the best available value for the velocity of sound under these conditions. The vapor density in the boiler is an independent datum and furnishes another means of computation, whose result indicates more conclusively that the assumptions of flow are verified as nearly as could be expected from the present incomplete knowledge of the properties of mercury vapor.

Some of the advantages of a pump of this design are apparent, namely, that it has a single boiler run by a single gas burner, a single line of cooling water, and is effectively a single unit with a direct air tight connection between the high vacuum stages. It is also noted that several paths conveniently open for free exhaustion with a fore pump are closed as soon as the mercury vapor pump is started. The advantage of not requiring a primary pressure less than 4 cm. is also apparent.

This type of pump could be employed in nearly all places where high vacuum is necessary. If mercury is objectionable either on account of its vapor pressure or its being an undesirable element in the region to be evacuated, the apparatus can be protected by a liquid air trap or possibly a gold foil trap. The speed of the pump when working on high vacuum can be increased by increasing the dimensions of the high vacuum unit. However, high speed, as has often been pointed out, is sometimes illusive, for a connecting tube 1 cm. in diameter and 0.5 meter long is

sufficient to cut the effective speed, of even as small a pump as the one described above, down to half, while a pump capable of infinite speed working through such a connection could only do as well as could the pump described above without such connecting tube.

When the time of initially reaching a sufficiently low pressure for the high vacuum pump to be effective becomes of importance the fore pumps can be made faster; however, this element is not often of so much consequence, for even a small water aspirator, working properly, in conjunction with the intermediate pump, will, in about five minutes, pump a volume of one liter down to a pressure sufficiently low for the high vacuum pump to begin effective operation and will pump larger volumes in proportionately longer times.

PHYSICS.—*Probe-wire measurements of anode fall of potential.*

JOHN T. TATE and PAUL D. FOOTE, Bureau of Standards.

In connection with some work which the writers have in progress it was necessary to observe the amount of energy dissipated at the anode in a Wehnelt discharge tube. For this purpose a probe wire, or sound, was inserted in the anode glow and measurements were made upon the current flowing and upon the potential drop between the anode and sound.

In discharge tubes of this type it is easily possible to secure currents of several amperes with an anode fall of twenty volts or less. If the probe-wire circuit may be considered as obeying the ordinary laws of metallic circuits, it might at first appear that the resistance between the probe and the anode is small enough to permit accurate potential measurements by use of a high-resistance voltmeter instead of an electrometer. It was found, however, that the voltmeter readings were quite different from the electrometer readings.

Two explanations of this fact may be offered. That the probe wire on open circuit actually takes up the potential of the space surrounding it has been fairly well established.[1] On closed circuit the probe either takes up the potential of the

[1] SKINNER. Phys. Rev., **9**: 97. 1917.

surrounding space or it does not. If we first assume that the probe wire, with a small current flowing through it, does acquire the potential of the surrounding space, or anode glow, then the power supplied to the anode by the main discharge current may be obtained by using the voltmeter reading. The voltmeter

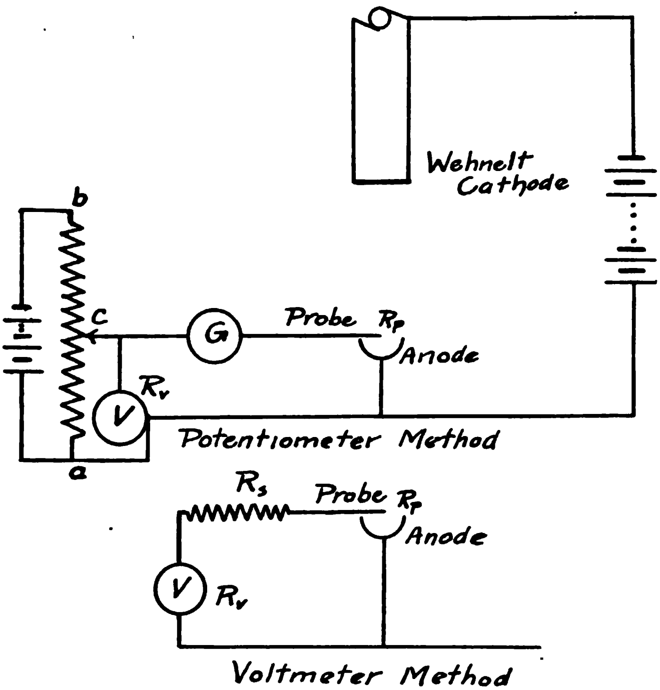

Fig. 1. Diagram of connections

readings are much smaller than the electrometer readings. Hence on the above assumption less power is developed at the anode while the voltmeter is connected. Since the potentials of the anode and cathode are fixed in the present experiment, the potential of the probe wire and anode glow must rise during the time the voltmeter is connected. The potential difference between the probe and cathode increases and, the main discharge current remaining constant, the difference in power developed at the anode in the two cases of electrometer and

voltmeter measurements must appear somewhere between the probe and the cathode.

The second assumption which may be made, and which the writers believe they have proved to be the correct explanation, is that the probe wire carrying a current does not take up the

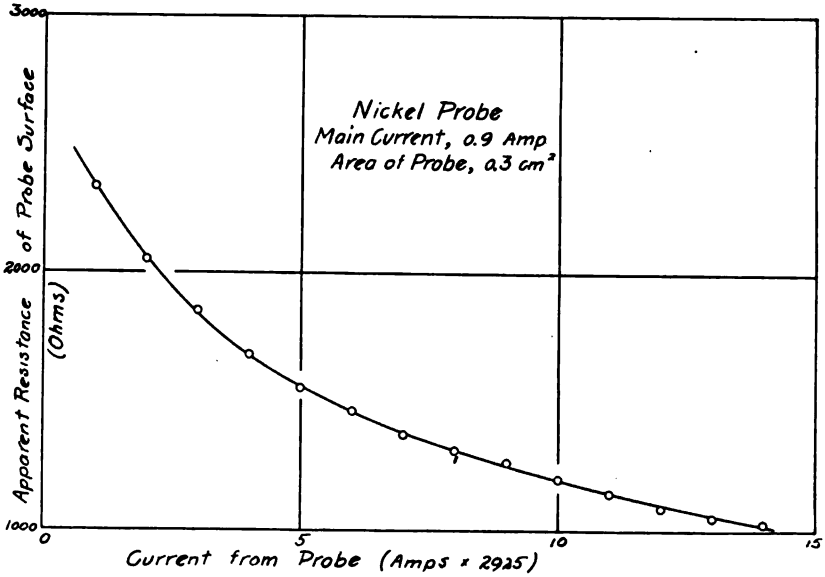

Fig. 2. Relation between the surface resistance and the current

potential of the space surrounding it. This would be the case if the probe were surrounded by a high-resistance film. Such films are known to exist[2] at the cathode, but the writers are not aware of measurements showing the presence of films at the anode. Any surface resistance of the probe must be due to its functioning as a secondary anode since the probe acts as a cathode through a metallic circuit alone.

In order to show the existence of a surface film at the probe, the apparatus was arranged as illustrated by figure 1.

The true anode drop was measured by using a potentiometric method, suggested by Dr. Swann, by adjusting the slide wire *c* for zero current in the galvanometer *G* and observing the read-

[2] Skinner. Loc. cit.

ing of the voltmeter V. In the voltmeter method the relation was obtained between the variable resistance R_s and the voltmeter reading. If a film of resistance R_p exists at the probe the relation between the observed voltmeter reading V' and the voltage drop on open circuit, V, is as follows:

$$V = V' \frac{R_v + R_r + R_p}{R_v}$$

From this equation R_p, the film resistance, is readily obtained.

The values observed are plotted in figure 2. It appears that the film resistance decreases with increasing current through the probe for the range of currents used. Since the probe acts as an anode during voltmeter readings evidence has been obtained for the existence of an anode polarization similar to the polarization at the cathode in a highly ionized gas, as observed by Skinner. The present experiment would not distinguish between a true polarization and a secondary anode fall at the probe. This latter might be developed by the voltmeter current and, although the current is very small, might amount to several volts since, as is well known, the ordinary anode fall is pronounced even for minute currents. However, as Skinner has remarked, it is scarcely conceivable that a potential gradient could exist in a highly ionized space. The conditions relating to the true anode and the secondary anode, or probe, are not similar, since the ionization in the space surrounding the probe must be due almost entirely to the main current.

The proof that the first explanation of the difference in voltmeter and electrometer or potentiometer readings can not be correct may be had in the following experiment.

The temperature of the anode is a measure of the power expended in it. The anode was made in the form of a crucible and filled with tin—a very nonvolatile metal. The temperature of the molten tin was measured by a minute rare-metal thermocouple. A series of measurements showed that the temperature of the anode (and hence the power dissipated there) remained the same whether the voltmeter or potentiometer was connected to the probe, although the power measurements by

the voltmeter were 20 per cent less than those by the potentiometer. If the voltmeter readings were a correct indication of the potential of the probe, it would require that 20 per cent of the total energy be expended between the probe and cathode and radiated back to the crucible. Even if we make the most favorable assumption that all of this energy is expended at the probe, since the crucible subtends a solid angle of 2π at the probe while the radiation from the probe must take place through 4π, it is evident that only half of this energy, or 10 per cent of the total energy, could reach the anode, still leaving 10 per cent to be accounted for. This amount of energy was several times greater than possible errors of observation. Furthermore, the bright tin surface possesses such a high reflection coefficient that undoubtedly very little energy could be absorbed were it present in the form of radiation. Still further, one would have to explain how a probe carrying a thousandth or less of the main current could produce a potential fall for the entire current in a space already completely ionized.

Conclusion. A film of high resistance forms at the surface of a probe placed in the anode glow. If a voltmeter is employed for the measurement of anode fall, the readings must be corrected to allow for the potential drop through this high-resistance film. Such a correction would be impracticable on account of the varying nature of the film.

Since the probe functions as an anode during voltmeter readings, evidence has been obtained for the existence of an anode polarization similar to the polarization at the cathode in a highly ionized gas, as observed by Skinner. The magnitude of the anode polarization is very much less than the cathode polarization. This explains the fact observed by Skinner that in an auxiliary transverse discharge through the cathode glow the resistance and the current potential curves are characteristic of the auxiliary *cathode* employed.

RADIOTELEGRAPHY.—*Notes on the audion.* L. W. AUSTIN, U. S. Naval Radiotelegraphic Laboratory.

A number of observations on the deForest Hudson filament audion have been made at the U. S. Naval Radiotelegraphic Laboratory, which may be of general interest.

The gas pressure used in audion detectors is generally below 0.001 mm. of mercury. By substituting nitrogen for air, to prevent the burning out of the filament, it has been found possible to construct detectors at all pressures up to that of the atmosphere. The action at 3 mm. is entirely normal. Local oscillations are easily produced and the sensitiveness is fully as great, both for continuous and damped signals, as at the usual pressure. At 10 mm. the sensitiveness is about normal, but local oscillations are more difficult to produce. In the neighborhood of atmospheric pressure no local oscillations have been observed, and the sensitiveness to spark signals is much less than at the low pressures. The conditions in this case would undoubtedly be much improved by bringing the electrodes closer together. Even with the ordinary arrangement of electrodes, the changes in the grid and plate currents due to the incoming waves are similar to those observed in the usual vacuum. With 200 volts, the plate current amounts to 20 or 30 microamperes.

Another series of observations has been made on the effect of the direct current voltage between the grid and filament on grid and plate signals. By grid and plate signals are meant the changes in grid and plate current brought about by an impressed alternating e.m.f. In the case of radio frequency signals a tuned closed circuit is connected in the usual way to the filament and through a stopping condenser to the grid. In this case the stopping condenser is shunted by a circuit containing a potentiometer for varying the D. C. grid potential and a galvanometer for measuring the grid current. In the case of low frequency excitation no tuned circuit is used but the filament is connected to the grid through the direct current potentiometer already mentioned, the galvanometer, and a slide wire alternating current potentiometer from which the required alternating voltage

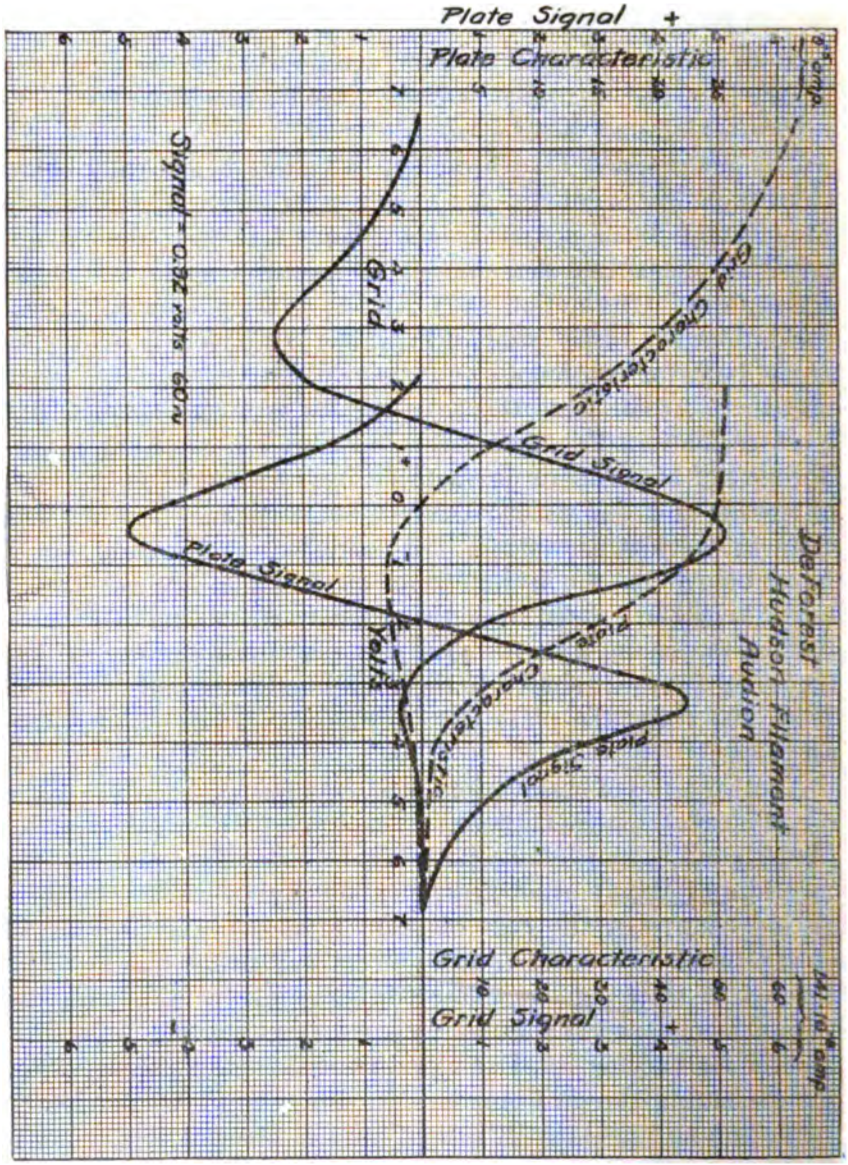
Plate Signal +
Plate Characteristic
Grid Characteristic
Grid Signal +
Grid Signal
Plate Signal
Grid Characteristic
Plate Characteristic
Grid
Plate
DeForest
Hudson Filament
Audion
Signal = 0.32 volts 60~

Fig. 1

is applied to the circuit. In both cases the plate circuit contains the usual dry cell battery of about 25 volts, the telephones, and a galvanometer for the measurement of the plate current. In the observations shown in figure 1 the gas pressure is that usually found in bulbs of this type.

The figure shows the grid and plate characteristics and also the grid and plate signals as defined above. The alternating e.m.f. in this case was 0.92 volt, with a frequency of 60 cycles. In the neighborhood of zero D. C. grid voltage the usual decrease of plate current and increase of grid current are noted, while with changing grid voltage the signals change both in magnitude and sign. These changes are apparently to be explained by the changes in curvature of the two characteristics.

The same curves are obtained if undamped radio frequency excitation of the same strength is used in place of the 60 cycles. In this case the grid galvanometer is shunted with a low non-inductive resistance to allow the oscillations to pass freely. Here the stopping condenser plays little part. If, however, a megohm is placed in series with the grid galvanometer so as to force the oscillations through the stopping condenser, the appearance of the curves is much changed. The grid signal is positive and nearly uniform over a wide range of grid D. C. voltage, while the plate signal is similarly negative except for strongly negative grid where both signals reverse slightly. Apparently here some other effects appear in addition to those due to the changes in grid and plate characteristics.

This work is still in progress and will be described later at greater length.

REFERENCES

Under this heading it is proposed to include, by author, title, and citation, references to scientific papers published in or emanating from Washington. It is requested that authors cooperate with the editors by submitting titles promptly, following the style used below. These references are not intended to replace the more extended abstracts published elsewhere in this JOURNAL.

PALEONTOLOGY

BERRY, E. W. *The flora of the Catahoula sandstone.* U. S. Geol. Surv. Prof. Paper **98M**: 227–251, pls. 55–60. August 23, 1916.

BERRY, E. W. *The flora of the Citronella formation.* U. S. Geol. Surv. Prof. Paper **98L**: 193–208, pls. 45–47. September 11, 1916.

KNOWLTON, F. H. *A lower Jurassic flora from the upper Matanuska Valley, Alaska.* Proc. U. S. Nat. Mus., **51**: 451–460, pls. 79–82. December 16, 1916.

KNOWLTON, F. H. *A new fossil Selaginella from the lower Tertiary of Montana.* Torreya, **16**: 201–204, pl. 1. September 14, 1916.

KNOWLTON, F. H. *A review of the fossil plants in the United States National Museum from the Florissant Lake beds at Florissant, Colorado, with descriptions of new species and list of type-specimens.* Proc. U. S. Nat. Mus., **51**: 241–297, pls. 12–27. November 24, 1916.

WHERRY, E. T. *Two new fossil plants from the Triassic of Pennsylvania.* Proc. U. S. Nat. Mus., **51**: 327–329, pls. 29–30. November 24, 1916.

BOTANY

BARTLETT, H. H. *The botanical work of Edward Lee Greene.* Torreya, **16**: 151–175, with portrait. July, 1916.

BARTLETT, H. H. Parthenium Lloydii, *a new Mexican guayule.* Torreya, **16**: 45, 46. February 26, 1916.

BRIGGS, L. J., JENSEN, C. A., and MCLANE, J. W. *Mottle-leaf of Citrus trees in relation to soil conditions.* Journ. Agr. Research, **6**: 721–740, pls. H, 96, 97, figs. 1–4. August 7, 1916.

CARRIER, L. *The identification of grasses by their vegetative characters.* U. S. Dept. Agr. Bull. **461**: 1–30, figs. 1–60. January 19, 1917.

CHASE, A. *The structure of the spikelet of Aphanelytrum.* Bot. Gaz., **61**: 340–343, fig. 1. April 18, 1916.

CHRISTENSEN, C. *Maxonia, a new genus of tropical American ferns.* Smithsonian Misc. Coll., **66**: 1–4. September 30, 1916.

COOK, O. F. *Branching and flowering habits of cacao and patashte.* Contr. U. S. Nat. Herb., **17**: 609–625, pls. 44–54. June 28, 1916.

COOK, O. F., and COOK, A. C. *Polar bear cacti.* Journ. Heredity, **8**: 113–120, figs. 3–8. February 27, 1917.

COOK, O. F., and DOYLE, C. B. *Germinating coconuts.* Journ. Heredity, **7**: 148–157, figs. 1–6. April, 1916.

CRON, A. B. *Triple-seeded spikelets in sorghum.* Journ. Amer. Soc. Agron., **8**: 237, 238, pl. 8. August 1, 1916.

EGGLESTON, W. W. *Additions and corrections to the new Vermont flora.* Vermont Bot. Bird Clubs, Joint Bull., **2**: 9–13. April, 1916.

GOLDMAN, E. A. *Plant records of an expedition to Lower California.* Contr. U. S. Nat. Herb., **16**: i–xiii + 309–371, pls. 104–133 + map. February 10, 1916.

GRANTHAM, A. E., and GROFF, F. *Occurrence of sterile spikelets in wheat.* Journ. Agr. Research, **6**: 235–250, pl. 27. May 8, 1916.

MCATEE, W. L. *Plants collected on Matinicus Island, Maine, in late fall, 1915.* Rhodora, **18**: 29–45. March 13, 1916.

MCATEE, W. L. *Some local names of plants—2.* Torreya, **16**: 235–242. December 9, 1916.

MCATEE, W. L. *The winter flora of Muskeget Island, Massachusetts.* Rhodora, **18**: 93–99. May 4, 1916.

MAXON, W. R. *Studies of tropical American ferns—No. 6.* Contr. U. S. Nat. Herb., **17**: 541–608 + i–viii, pls. 32–43. May 23, 1916.

OAKLEY, R. A. and GARVER, S. Medicago falcata, *a yellow-flowered alfalfa.* U. S. Dept. Agr. Bull. **428**: 1–70, pls. 1–4, figs. 1–23. January 9, 1917.

PIPER, C. V. *New plants from Oregon.* Proc. Biol. Soc. Washington, **29**: 99–102. June 6, 1916.

PIPER, C. V. *Notes on Quamasia with a description of a new species.* Proc. Biol. Soc. Washington, **29**: 77–82. April 4, 1916.

PITTIER, H. *New or noteworthy plants from Colombia and Central America—5.* Contr. U. S. Nat. Herb., **18**: i–ix + 143–171, pls. 57–80, figs. 88–97. March 3, 1916.

PITTIER, H. *Preliminary revision of the genus Inga.* Contr. U. S. Nat. Herb., **18**: 173–223 + i–ix, pls. 81–105. October 30, 1916.

RICKER, P. L. *Two types of variable pubescence on plants.* Amer. Journ. Bot., **3**: 470–473. October 20, 1916.

ROSE, J. N. Cremnophila nutans. Addisonia, **1**: 49, pl. 25. September 30, 1916.

ROSE, J. N. Echeveria cornicolor. *Flesh-colored Echeveria.* Addisonia, **1**: 25, pl. 13. June 30, 1916.

ROSE, J. N. Echeveria setosa. Addisonia, **1**: 11, pl. 6. March 31, 1916.

ROSE, J. N. Pachyphytum longifolium. Addisonia, **1**: 7, 8, pl. 4. March 31, 1916.

ROSE, J. N. *Recent explorations in the cactus deserts of South America.* Proc. Nat. Acad. Sci., **2**: 73, 74. February, 1916.

ROSE, J. N. Sedum diversifolium. Addisonia, **1**: pl. 31 A. December 30, 1916.

ROSE, J. N. Sedum humifusum. Addisonia, **1**: pl. 31 B. December 30, 1916.

SAFFORD, W. E. *The botanical identity of Lignum nephriticum.* Science, II., **43**: 432. March 24, 1916.

SAFFORD, W. E. *Desmopsis, a new genus of Annonaceae.* Bull. Torrey Club, **43**: 183–193, pls. 7–9, fig. 1. May 20, 1916.

STANDLEY, P. C. *Additional notes upon New Mexican Hepaticae.* Bryologist, **19**: 64, 65. July 25, 1916.

STANDLEY, P. C. *Chenopodiaceae.* N. Amer. Fl., **21**: 3–93. November 27, 1916.

STANDLEY, P. C. *Chenopodiales.* N. Amer. Fl., **21**: 1, 2. November 27, 1916.
STANDLEY, P. C. *The ferns of Greene County, Missouri.* Amer. Fern Journ., **6**: 44–51. June, 1916.
STANDLEY, P. C. *The genus Choisya.* Proc. Biol. Soc. Washington, **27**: 221–224. December 29, 1914.
STANDLEY, P. C. *Some ferns of Dutchess County, New York.* Amer. Fern Journ., **6**: 1–7. March 1916.
STANDLEY, P. C. *Studies of tropical American phanerogams.* Contr. U. S. Nat. Herb., **18**: 87–142, i–x. February 11, 1916.
TIDESTROM, I. Allium platyphyllum sp. nov. Torreya, **16**: 242, 243. December 9, 1916.
TIDESTROM, I. Myosurus aristatus Benth. Torreya, **16**: 228–230, fig. 1. November 16, 1916.

FORESTRY

HUMPHREY, C. J. *Laboratory tests on the durability oj American woods—I. Flask tests on conifers.* Mycologia, **8**: 80–92, pl. 183. April 11, 1916.
SPAULDING, P. *Foresters have a vital interest in the white-pine blister rust.* Proc. Soc. Amer. Foresters, **11**: 40–47. January, 1916.
SPAULDING, P., and HARTLEY, C. *Safety first in tree planting.* Amer. Forest., **22**: 665–669. November, 1916. [Illust.]
SUDWORTH, G. B. *The spruce and balsam fir trees of the Rocky Mountain region.* U. S. Dept. Agr. Bull. **327**: 1–43, pls. 1–25 + maps 1–10. February 19, 1916.
YOUNG, R. A., and POPENOE, P. *Saving the kokio tree.* Journ. Heredity, **7**: 24–28, figs. 6, 7. December 29, 1915.

PHYTOPATHOLOGY

ALLARD, H. A. *The mosaic disease of tomatoes and petunias.* Phytopathology, **6**: 328–335, figs. 1–2. September 12, 1916.
ALLARD, H. A. *A specific mosaic disease in* Nicotiana viscosum *distinct from the mosaic disease of tobacco.* Journ. Agr. Research, **7**: 481–486, pls. 35, 36. December 11, 1916.
BIOLETTI, F. T., and BONNET, L. *Little-leaf of the vine.* Journ. Agr. Research, **8**: 381–398, pls. 89–92, figs. 1–2. March 6, 1917.
BOYCE, J. S. *A note on* Cronartium pyriforme. Phytopathology, **6**: 202, 203. April 4, 1916.
BOYCE, J. S. *Pycnia of* Cronartium pyriforme. Phytopathology, **6**: 446, 447. December, 1916.
BROWN, H. B. *Life history and poisonous properties of* Claviceps Paspali. Journ. Agr. Research, **7**: 401–406, pl. 32, figs. 1, 2. November 27, 1916.
BYARS, L. P. Tylenchus tritica *on wheat.* Phytopathology, **7**: 56, 57. February 7, 1917.
CARPENTER, C. W. *The Rio Grande lettuce disease.* Phytopathology, **6**: 303–305, fig. 1. June 1916.
COLLEY, R. H. *Discovery of internal telia produced by species of Cronartium.* Journ. Agr. Research, **8**: 329–332, pl. 88. February 26, 1917.
CROMWELL, R. O. *Fusarium-blight or wilt disease of the soybean.* Journ. Agr. Research, **8**: 421–440, pl. 95, fig. 1. March 12, 1917.

CULPEPPER, C. W., FOSTER, A. C., and CALDWELL, J. S. *Some effects of the blackrot fungus,* Sphaeropsis malorum, *upon the chemical composition of the apple.* Journ. Agr. Research, **7**: 17–40. October 2, 1916.

EDSON, H. A. *Histological relations of sugar-beet seedlings and* Phoma betae. Journ. Agr. Research, **5**: 55–58, pls. 1–2. October 4, 1915.

FAULWETTER, R. C. *Dissemination of the angular leafspot of cotton.* Journ. Agr. Research, **8**: 457–475, figs. 1, 2. March 19, 1917.

GILBERT, W. W. *Cucumber mosaic disease.* Phytopathology, **6**: 143, 144, pl. 5. April 4, 1916.

HARTER, L. L. *Rhizoctonia and* Sclerotium rolfsii *on sweet potatoes.* Phytopathology, **6**: 305, 306. June, 1916.

HARTER, L. L. *Storage-rots of economic aroids.* Journ. Agr. Research, **6**: 549–572, pls. 81–83, fig. 1. July 10, 1916.

HARTER, L. L. *Sweet-potato diseases.* U. S. Dept. Agr. Farmers' Bull. **714**: 1–26, figs. 1–21. March 11, 1916.

HARTER, L. L. *Sweet-potato scurf.* Journ. Agr. Research, **5**: 787–792, pls. 57, 58. January 24, 1916.

HAWKINS, L. A. *The disease of potatoes known as "leak."* Journ. Agr. Research, **6**: 627–640, pl. 90, fig. 1. July 24, 1916.

HAWKINS, L. A. *Effect of certain species of Fusarium on the composition of the potato tuber.* Journ. Agr. Research, **6**: 183–196. May 1, 1916.

HEDGCOCK, G. G. *Identity of* Peridermium montanum *with* Peridermium acicolum. Phytopathology, **6**: 64–67. February 9, 1916.

HEDGCOCK, G. G., and HUNT, N. R. Dothichiza populae *in the United States.* Mycologia, **8**: 300–308, pls. 194, 195. November 3, 1916.

JACKSON, H. S. *An Asiatic species of Gymnosporangium established in Oregon.* Journ. Agr. Research, **5**: 1003–1010, pls. 78, 79. February 28, 1916.

JOHNSON, J. *Host plants of* Thielavia vasicola. Journ. Agr. Research, **7**: 289–300, pls. 18, 19. November 6, 1916.

KELLERMAN, K. F. *Cooperation in the investigation and control of plant diseases.* Mem. N. Y. Bot. Gard., **6**: 517. August 31, 1916.

KUNKEL, L. O. *Further studies of the orange rusts of Rubus in the United States.* Bull. Torrey Club, **43**: 559–569, figs. 1–5. November 27, 1916.

LONG, W. H. *The aecial stage of* Coleosporium ribicola. Mycologia, **8**: 309–311. November 3, 1916.

MCKEE, R. *Alfalfa crown wart in the western United States.* Journ. Amer. Soc. Agron., **8**: 244–246. August 1, 1916.

MEIER, F. C. *Watermelon stem-end rot.* Journ. Agr. Research, **6**: 149–152, pl. 17. April 24, 1916.

MEINECKE, E. P. Peridermium harknessii *and* Cronartium Quercuum. Phytopathology, **6**: 225–240, figs. 1, 2. June 1916.

MELHUS, I. E., ROSENBAUM, J., and SCHULTZ, E. S. *Studies of* Spongospora subterranea *and* Phoma tuberosa *of the Irish potato.* Journ. Agr. Research, **7**: 213–254, pl. A, 7–14, fig. 1. October 30, 1916.

METCALF, H. *Spread of the chestnut blight in Pennsylvania.* Phytopathology, **6**: 302. June 1916.

MORSE, W. J. *Studies upon the blackleg disease of the potato, with special reference to the relationship of the causal organisms.* Journ. Agr. Research, **8**: 79–126. January 15, 1917.

PATTERSON, F. W., and CHARLES, V. K. *The occurrence of bamboo smut in America.* Phytopathology, **6**: 351–356, fig. 1. September 12, 1916.

PIERCE, R. G. *Albany conference on white-pine blister rust.* Phytopathology, **7**: 54, 55. February 7, 1917.

PIERCE, R. G. Pinus resinosa, *a new host for* Peridermium acicolum. Phytopathology, **6**: 302, 303. June, 1916.

PIERCE, R. G., and HARTLEY, C. *Horse-chestnut anthracnose.* Phytopathology, **6**: 93. February 9, 1916.

POOL, V. W., and MCKAY, M. B. *Climatic conditions as related to* Cercospora beticola. Journ. Agr. Research, **6**: 21–50, pls. 3, 4, figs. 1–10. April 3, 1916.

POOL, V. W., and MCKAY, M. B. *Relation of stomatal movement to infection by* Cercospora beticola. Journ. Agr. Research, **5**: 1011–1038, pls. 30, 31, figs. 1–6. February 28, 1916.

PRATT, O. A. *A western fieldrot of the Irish potato tuber caused by* Fusarium radicicola. Journ. Agr. Research, **6**: 297–310, pls. 34–37. May 29, 1916.

RAND, F. V. *Leafspot-rot of pond lilies caused by* Helicosporium nymphaearum. Journ. Agr. Research, **8**: 219–232, pls. 67–70. February 5, 1917.

RAND, F. V., and ENLOWS, E. M. A. *Transmission and control of bacterial wilt of cucurbits.* Journ. Agr. Research, **6**: 417–434, pls. 53, 54, figs. 1–3. June 12, 1916.

ROBERTS, J. W. *Sources of the early infections of apple bitterrot.* Journ. Agr. Research, **4**: 59–64, pl. 7. April 15, 1915.

ROSEN, H. R. *The development of* Phylloxera vestatrix *leaf gall.* Amer. Journ. Bot., **3**: 337–360, pls. 14, 15, figs. 1–5. August, 1916.

ROSEN, H. R. A *known species of smut on a new host.* Mycologia, **8**: 225, 226. July 15, 1916.

SHEAR, C. L., and STEVENS, N. E. *The discovery of the chestnut-blight parasite* (Endothia parasitica) *and other chestnut fungi in Japan.* Science, II. **43**: 173–176. February 4, 1916.

SHEAR, C. L., STEVENS, N. E., and TILLER, R. J. Endothia parasitica *and related species.* U. S. Dept. Agr. Bull. **380**: 1–82, pls. 1–23, figs. 1–5. January 15, 1917.

SMITH, E. F. *Banana diseases in Cuba.* Hawaiian Forest. Agr. Month. Mag., **8**: 33–35. January, 1911.

SMITH, E. F. *Crown gall studies showing changes in plant structure due to a changed stimulus.* Journ. Agr. Research, **6**: 179–182, pls. 18–23. April 24, 1916.

SMITH, E. F. *Further evidence as to the relation between crown gall and cancer.* Proc. Nat. Acad. Sci., **2**: 444–448. August, 1916.

SMITH, E. F. *Further evidence that crown gall of plants is cancer.* Science, II. **43**: 871–889. June 23, 1916.

SMITH, E. F. *Mechanism of tumor growth in crown gall.* Journ. Agr. Research, **8**: 165–188, pls. 4–65. January 29, 1917.

SMITH, E. F. *Studies on the crown gall of plants; its relation to human cancer.* Journ. Cancer Research, **1**: 231–309, pls. 1–25. April, 1916.

SMITH, E. F. *Tumors in plants.* Science, II. **44**: 611, 612. October 27, 1916.

SPAULDING, P. *The blister rust disease of white pine.* Amer. Forest., **22**: 97, 98, figs. A–D. February, 1916.

SPAULDING, P. *Notes on* Cronartium comptoniae—*III.* Phytopathology, **7**: 49–51. February 7, 1917.

SPAULDING, P. *The white-pine blister rust.* U. S. Dept. Agr. Farmers' Bull. **742**: 1–15, pls. 1, figs. 1–4. June 9, 1916.

SPAULDING, P., DETWILER, S. B., PETTIS, C. R., and METCALF, H. *The white-pine blister disease.* Amer. Forest., **23**: 67–74. February, 1917. [Illust.]

SPEARE, A. T. Sorosporella uvella *and its occurrence in cutworms in America.* Journ. Agr. Research, **8**: 189–194, pl. 66, fig. 1. February 5, 1917.

STANDLEY, P. C. *Fungi of New Mexico.* Mycologia, **8**: 142–177. May 23, 1916.

STEVENS, N. E. *The influence of certain climatic factors on the development of* Endothia parasitica (Murr.) And. Amer. Journ. Bot., **4**: 1–32, figs. 1–3. February 3, 1917.

STEVENS, N. E. *The influence of temperature on the growth of* Endothia parasitica. Amer. Journ. Bot., **4**: 112–118, fig. 1. February 17, 1917.

STEVENS, N. E. *Pathological histology of strawberries affected by species of Botrytis and Rhizopus.* Journ. Agr. Research, **6**: 361–366, pls. 49, 50. June 5, 1916.

TAUBENHAUS, J. J. *Soil stain, or scurf of the sweet potato.* Journ. Agr. Research, **5**: 995–1002, pls. 76–77. February 21. 1916.

THOM, C., and AYERS, S. H. *Effect of pasteurization on mold spores.* Journ. Agr. Research, **6**: 153–166, figs. 1–3. April 24, 1916.

THOM, C., and CURRIE, J. N. Aspergillus niger *group.* Journ. Agr. Research, **7**: 1–15. October 2, 1916.

WEIR, J. R. Hypoderma deformans, *an undescribed needlefungus of the western yellow pine.* Journ. Agr. Research., **6**: 277–288, pl. 32, figs. 1–4. May 22, 1916.

WEIR, J. R. Keithia thujina, *the cause of a serious leaf disease of the western red cedar.* Phytopathology, **6**: 360–363, figs. 1, 2. September 12, 1916.

WEIR, J. R. Phacidium infestans *on western conifers.* Phytopathology, **6**: 413, 414. October, 1916.

WEIR, J. R. Pinus ponderosa *and* P. jeffreyi, *hosts for* Razoumofskya americana. Phytopathology, **6**: 414. October, 1916.

WEIR, J. R., and HUBERT, E. E. *Inoculation experiments with* Peridermium montanum. Phytopathology, **6**: 68–70. February, 1916.

WEIR, J. R., and HUBERT, E. E. *A serious disease in forest nurseries caused by* Peridermium filamentosum. Journ. Agr. Research, **5**: 781–785. January 24, 1916.

WEIR, J. R., and HUBERT, E. E. *A successful inoculation of* Abies lasiocarpa *with* Pucciniastrum pustulatum. Phytopathology, **6**: 373. September 12, 1916.

WEIR, J. R., and HUBERT, E. E. *Successful inoculations of* Larix occidentalis *and* Larix europea *with* Melampspora bigelowii. Phytopathology, **6**: 372, 373. September 12, 1916.

WOLF, F. A. *Citrus canker.* Journ. Agr. Research, **6**: 69–100, pls. 8–11, figs. 1–8. April 10, 1916.

WOLF, F. A. *Further studies on peanut leafspot.* Journ. Agr. Research, **5**: 891–902. February 7, 1916.

WOLF, F. A. *A squash disease caused by* Choanephora cucurbitarum. Journ. Agr. Research, **8**: 319–328, pls. 85–87. February 26, 1917.

PLANT PHYSIOLOGY

Allard, H. A. *Effect of environmental conditions upon the number of leaves and the character of the inflorescence of tobacco plants.* Amer. Journ. Bot., **3**: 493–501, pls. 20–23. December 23, 1916.

Briggs, L. J., and Schantz, H. L. *Daily transpiration during the normal growth period and its correlation with the weather.* Journ. Agr. Research, **7**: 155–212, pls. 5, 6, figs. 1–18. October 23, 1916.

Briggs, L. J., and Schantz, H. L. *Influence of hybridization and cross-pollination on the water requirement of plants.* Journ. Agr. Research, **4**: 391–402, pl. 58, fig. 1. August 16, 1915.

Brooks, C., and Cooley, J. S. *Temperature relations of apple-rot fungi.* Journ. Agr. Research, **8**: 139–164, pls. 1–3, figs. 1–25. January 22, 1917.

Burlison, W. L. *Availability of mineral phosphates for plant nutrition.* Journ. Agr. Research, **6**: 485–514, pls. 73–80. June 26, 1916.

Clarke, F. W., and Wheeler, W. C. *The inorganic constituents of marine invertebrates.* U. S. Geol. Surv. Prof. Paper **102**: 1–56. 1917.

Clements, F. C. *Plant succession. An analysis of the development of vegetation.* Carnegie Inst. Publ. **242**: i-xiii + 1–512, pls. 1–61, figs. 1–51. August 28, 1916.

Cook, F. C. *Boron: its absorption and distribution in plants and its effects on growth.* Journ. Agr. Research, **5**: 877–890. February 7, 1916.

Fred, E. B. *Relation of carbon bisulphide to soil organisms and plant growth.* Journ. Agr. Research, **6**: 1–20, pls. 1–2. April 3, 1916.

Gile, P. L., and Carrero, J. O. *Assimilation of iron by rice from certain nutrient solutions.* Journ. Agr. Research, **7**: 503–528. December 18, 1916.

Gile P. L., and Carrero, J. O. *Immobility of iron in the plant.* Journ. Agr. Research, **7**: 83–87. October 9, 1916.

Harris, J. A., and Popenoe, W. *Freezing-point lowering of the leaf sap of the horticultural types of* Persea americana. Journ. Agr. Research, **7**: 261–268. November 6, 1916.

Hawkins, L. A. *Growth of parasitic fungi in concentrated solutions.* Journ. Agr. Research, **7**: 255–260. October 30, 1916.

Hawkins, L. A. *The influence of calcium, magnesium, and potassium nitrates upon the toxicity of certain heavy metals toward fungus spores.* Physiol. Researches, **1**: 57–92, figs. 1–6. August, 1913.

Headley, F. B., Curtis, E. W., and Scofield, C. S. *Effect on plant growth of sodium salts in the soil.* Journ. Agr. Research, **6**: 857–869, figs. 1–8. August, 28, 1916.

Lamb, A. R. *The relative influence of microorganisms and plant enzymes on the fermentation of corn silage.* Journ. Agr. Research, **8**: 361–380, figs. 1–13. March 6, 1917.

Lathrop, E. C. *The generation of aldehydes by* Fusarium cubense. Phytopathology, **7**: 14–15. February 7, 1917.

Lipman, C. B., Burgess, P. S., and Klein, M. A. *Comparison of the nitrifying powers of some humid and some arid soils.* Journ. Agr. Research, **7**: 47–82. October 9, 1916.

Macbride, J. F. *Vegetative succession under irrigation.* Journ. Agr. Research, **6**: 741–760, pls. 98–105. August 7, 1916.

MARTIN, W. H. *Influence of Bordeaux mixture on the rates of transpiration from abscised leaves and from potted plants.* Journ. Agr. Research, **7**: 529–548. December 18, 1916.

MILLER, E. C. *Comparative study of the root systems and leaf areas of corn and the sorghums.* Journ. Agr. Research, **6**: 311–332, pls. 38–44, figs. 1–3. May 29, 1916.

STEVENS, N. E. *A method for studying the humidity relations of fungi in culture.* Phytopathology, **6**: 428–432. December, 1916.

STEVENS, N. E. *Recovery of a tree from a lightning stroke.* Phytopathology, **6**: 204–206. April 4, 1916.

TRUE, R. H., and BARTLETT, H. H. *The exchange of ions between the roots of* Lupinus albus *and culture solutions containing three nutrient salts.* Amer. Journ. Bot., **3**: 47–57, figs. 1–3. March 4, 1916.

TRUE, R. H., and STOCKBERGER, W. W. *Physiological observations on alkaloids, latex, and oxidases in* Papaver somniferum. Amer. Journ. Bot., **3**: 1–11. February 5, 1916.

WYATT, F. A. *Influence of calcium and magnesium compounds on plant growth.* Journ. Agr. Research, **6**: 589–620, pls. 84–88. July 17, 1916.

GENETICS

BARTLETT, H. H. *The status of the mutation theory, with especial reference to Oenothera.* Amer. Nat., **51**: 513–529. September, 1916.

COLLINS, G. N. *Correlated characters in maize breeding.* Journ. Agr. Research, **6**: 435–454, pls. 53–63. June 19, 1916.

COLLINS, G. N., and KEMPTON, J. H. *Parthenogenesis.* Journ. Heredity, **7**: 106–118, figs. 2–9. March, 1916.

KEMPTON, J. H. *Lobed leaves in maize.* Journ. Heredity, **7**: 508–510, fig. 11. November, 1916.

LAMB, W. H. *Hybrid trees.* Journ. Heredity, **7**: 311–319, figs. 12–15. June 26, 1916.

LA RUE, C. D., and BARTLETT, H. H. *Matroclinic inheritance in mutation crosses of* Oenothera Reynoldsii. Amer. Journ. Bot., **4**: 119–144, figs. 1–4. March, 1917.

SHAMEL, A. D. *Bud variation.* Journ. Heredity, **7**: 82–87, fig. 8. January 25, 1916.

ORNITHOLOGY

——. *Opinions rendered by the International Commission on Zoological Nomenclature. Opinion 67.* Smith. Inst. Publ. **2419**: 177–182. April, 1916. (One hundred and two generic names of birds are added to the official list of generic names.—C. W. R.)

BAILEY, F. M. *Characteristic birds of the Dakota prairies. I. In the grassland.* Condor, **17**: 173–179. October 10, 1915.

BAILEY, F. M. *Characteristic birds of the Dakota prairies. II. Along the lake borders.* Condor, **17**: 222–226. November 30, 1915.

BAILEY, F. M. *Characteristic birds of the Dakota prairies. III. Among the sloughs and marshes.* Condor, **18**: 14–21. January 15, 1916.

BAILEY, F. M. *Characteristic birds of the Dakota prairies. IV. On the lakes.* Condor, **18**: 54–58. March 30, 1916.

BAILEY, F. M. *A populous shore.* Condor, **18**: 100–110. June 8, 1916. (Account of water birds observed near Venice, California.—C. W. R.)

BAILEY, F. M. *A Brewer blackbird roost in redlands.* Wilson Bull., **28**: 51–58. June, 1916.

BAILEY, F. M. *A home in the forest.* Bird-Lore, **18**: 229–233. July–August, 1916. (Account of the nesting of the Sierra creeper in Oregon.—C. W. R.)

BAILEY, F. M. *Meeting spring half way. I.* Condor, **18**: 151–155. July 20, 1916.

BAILEY, F. M. *Meeting spring half way. II.* Condor, **18**: 183–190. September 18, 1916.

BAILEY, F. M. *Black-headed grosbeaks eating butter.* Condor, **18**: 201. September 18, 1916.

BAILEY, F. M. *Screech owl Johnnie.* Bird-Lore, **18**: 306–310. September–October, 1916.

BAILEY, F. M. *Dick, the sandhill crane.* Bird-Lore, **18**: 355–356. November–December, 1916.

BAILEY, F. M. *Meeting spring half way. III.* Condor, **18**: 214–219. November 29, 1916. (Observations on the birds of Texas.—C. W. R.)

BAILEY, F. M. *Birds of the humid coast.* Condor, **19**: 8–13. January 15, 1917; **19**: 46–54. March 15, 1917; **19**: 95–101, June 1, 1917. (Observations made in northwestern Oregon.—C. W. R.)

BAILEY, F. M. *Handbook of birds of the western United States.* Seventh edition, revised. Houghton and Mifflin, Boston and New York, 1917. 8°.

BANGS, O. *Three new subspecies of birds from eastern Mexico and Yucatan.* Proc. Biol. Soc. Wash., **28**: 125, 126. May 17, 1915. (Describes *Tityra semifasciata deses*, *Turdus migratorius phillipsi*, and *Cyanocompsa parellina beneplacita*.—C. W. R.)

BARTSCH, P. *Birds observed on the Florida Keys from April 20 to 30, 1914.* Carnegie Instit. Wash., Year Book No. 13, 1915: 192–196.

BARTSCH, P. *Birds observed on the Florida Keys and along the railroad of the mainland from Key Largo to Miami, June 17 to July 1, 1915.* Carnegie Inst. Wash., Year Book No. 14, 1916: 197–199.

BARTSCH, P. *Birds observed in 1916, in the region of Miami and the Florida Keys from May 15 to June 4 and along the railroad from Key West to Miami on June 24.* Carnegie Inst. Wash., Year Book No. 15, 1917: 182–188.

BARTSCH, P. *Relationship of the Florida herons.* Auk, **34**: 86. January, 1917.

BARTSCH, P. *Destruction of passenger pigeons in Arkansas.* Auk, **34**: 87. January, 1917. (Letter from a correspondent, reporting destruction of pigeons by fire, about the year 1879.—C. W. R.)

BARTSCH, P. *Additions to the Haitian avifauna.* Proc. Biol. Soc. Wash., **30**: 131, 132. July 27, 1917. (Describes *Porzana flaviventris hendersoni* and revives *Dendroica petechia albicollis;* eleven other forms are listed as probably new to Haiti.—C. W. R.)

BEAL, F. E. L. *Some common birds useful to the farmer.* U. S. Dept. Agr., Farmers' Bulletin No. 630. Pp. 1–27, figs. 1–23. February 13, 1915.

BEAL, F. E. L., MCATEE, W. L., and KALMBACH, E. R. *Common birds of southeastern United States in relation to agriculture.* U. S. Dept. Agr., Farmers' Bulletin No. 755. Pp. 1–39, figs. 1–20. October 26, 1916.

COOKE, W. W. *The yellow-billed loon: a problem in migration.* Condor, **17:** 213, 214. November 30, 1915.

COOKE, W. W. *The type locality of* Brachyramphus craverii. Auk, **33:** 80. January, 1916. (Isla Raza, in Gulf of California, is shown to be the type locality of this species.—C. W. R.)

COOKE, W. W. *The migration of North American birds.* Bird-Lore, **18:** 14–16. January-February, 1916; **18:** 97, March-April, 1916.

COOKE, W. W. *Labrador bird notes.* Auk., **33:** 162–167. April, 1916. (Notes on forty-seven species.—C. W. R.)

COOKE, W. W. *The type locality of* Uria t. troille. Auk, **33:** 196. April, 1916. (Sweden, not Spitzbergen, is the type locality of this species.—C. W. R.)

COOKE, W. W. *The scissor-tailed flycatcher in New Mexico.* Auk, **33:** 324, 325. July, 1916.

COOKE, W. W. *Second annual report of bird counts in the United States, with discussion of results.* U. S. Dep. Agr., Bull. No. 396. Pp. 1–20, fig. 1. October 23, 1916. [Posthumous.]

GABRIELSON, I. N. *A criticism of two recent lists of Iowa birds.* Wilson Bull., **29:** 97–100. June, 1917.

GROSVENOR, G. H. *The world's record for density of bird population.* Bird-Lore, **18:** 77–84, 10 figs. 1916. (Fifty-nine pairs, twelve species, nesting on one acre.—C. W. R.)

HANNA, G. D. *Records of birds new to the Pribilof Islands including two new to North America.* Auk, **33:** 400–403. October, 1916. (Thirteen species are added to the avifauna of the Pribilofs, of which *Clangula c. clangula* and *Fringilla montifringilla* are also new to America.—C. W. R.)

HENSHAW, H. W. *Friends of our forests.* Nat. Geog. Mag., **31:** 297–321, 32 pls. (A synopsis of the warblers of North America, with colored illustrations of the species.—C. W. R.)

HERSEY, F. S. *A list of the birds observed in Alaska and northeastern Siberia during the summer of 1914.* Smiths. Misc. Coll., **62**^{2}: 1–33. 1916.

HOLLISTER, N. *The black vulture in the District of Columbia and Maryland.* Proc. Biol. Soc. Wash., **30:** 123. July 7, 1917.

LINCOLN, F. C. *A review of the genus Pediœcetes in Colorado.* Proc. Biol. Soc. Wash., **30:** 83–86. May 23, 1917. (Recognizes three forms in the State, of which *P. phasianellus jamesi* is new.—C. W. R.)

MCATEE, W. L. [*Letter to the editor.*] Wilson Bull., **27:** 339–344. June, 1915.

MCATEE, W. L. *An accomplishment of the red-throated loon.* Auk, **33:** 75. January, 1916. (Describes its ability to spring into the air from still water and proceed under normal flight.—C. W. R.)

MCATEE, W. L. *The rose beetle poisonous to young birds.* Auk, **33:** 205, 206. April, 1916.

MCATEE, W. L. *How to attract birds in northwestern United States.* U. S. Dept. Agri., Farmers' Bull. No. 760. Pp. 1–11. October 16, 1916.

MCATEE, W. L. *Some local names of birds.* Wilson Bull., **29:** 74–95. June, 1917.

MCATEE, W. L. *Life and writings of Professor F. E. L. Beal.* Auk, **34:** 243–264, pl. 6. July, 1917.

MEARNS, E.A. *The occurrence of the western house wren on Smith's Island, Northampton County, Virginia.* Auk, **33:** 203. April, 1916.

MEARNS, E. A. *Description of a new subspecies of the American least tern.* Proc. Biol. Soc. Wash., **29**: 71, 72. April 4, 1916. (Describes *Sterna antillarum browni.*—C. W. R.)

MEARNS, E. A. *On the geographical forms of the Philippine elegant titmouse,* Pardaliparus elegans (Lesson), *with descriptions of three new subspecies.* Proc. U. S. Nat. Mus., **51**: 57–65. October 16, 1916. (Recognizes seven forms, of which *P. e. panayensis, P. e. guimarasensis,* and *P. e. suluensis* are described as new.—C. W. R.)

OBERHOLSER, H. C. *The birds of Bawean Island, Java Sea.* Proc. U. S. Nat. Mus., **52**: 183–198. February 8, 1917. (Records twenty-six species, of which seven are here described as new.—C.W. R.)

OBERHOLSER, H. C. *Description of a new Sialia from Mexico.* Proc. Biol. Soc. Wash., **30**: 27, 28. February 21, 1917. (Describes *Sialia sialis episcopus.*—C. W. R.)

OBERHOLSER, H. C. *A cooperative bird census at Washington, D. C.* Wilson Bull., **29**: 18–20. March, 1917.

OBERHOLSER, H. C. *The number of species and subspecies of birds in Texas.* Condor, **19**: 68. March 15, 1917. (Six hundred and five forms.—C. W. R.)

OBERHOLSER, H. C. *Mutanda ornithologica. I.* Proc. Biol. Soc. Wash., **30**: 75, 76. March 31, 1917. (Makes five changes of names; *Cerchneis araea, C. alopex cremica,* and *Rallus adelus* are new.—C. W. R.)

OBERHOLSER, H. C. *Critical notes on the eastern subspecies of* Sitta carolinensis *Latham.* Auk, **34**: 181–187. April, 1917. (Recognizes two forms from eastern United States, of which *S. c. cookei* is new.—C. W. R.)

OBERHOLSER, H. C. *Notes on North American birds. I.* Auk, **34**: 191–196. April, 1917. (Discusses the status of eight species and subspecies.—C. W. R.)

OBERHOLSER, H. C. *Second annual list of proposed changes in the A. O. U. Check-List of North American Birds.* Auk, **34**: 198–205. April, 1917.

OBERHOLSER, H. C. *Diagnosis of a new laniine family of passeriformes.* Journ. Wash. Acad. Sci., **7**: 180, 181. April 4, 1917. (Tylidae is a new family, embracing the genus *Tylas.*—C. W. R.)

OBERHOLSER, H. C. [*Winter birds of the*] *Washington region.* Bird-Lore, **19**: 152. May-June, 1917.

OBERHOLSER, H. C. *Description of a new genus of Anatidæ.* Proc. Biol. Soc. Wash., **30**: 119, 120. May 23, 1917. (*Horizonetta* is proposed for *Anas laysanensis.*—C. W. R.)

OBERHOLSER, H. C. *The status of* Aphelocoma cyanotis *and its allies.* Condor, **19**: 94, 95. June 1, 1917.

OBERHOLSER, H. C. *Notes on the fringilline genus Passerherbulus and its nearest allies.* Ohio Journ. Sci., **17**: 332–336. June 2, 1917. (The genus is divided into four, of which *Thryospiza* and *Nemospiza* are new.—C. W. R.)

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, October 2: The Anthropological Society, at the Public Library, at 8 p.m.

Tuesday, October 2: The Botanical Society, at the Cosmos Club, at 8 p.m.

Tuesday, October 2: The Society of Engineers, at Rauscher's, 1034 Connecticut Ave., N. W., at 8 p.m.

Wednesday, October 3: The Medical Society, at the Medical Department of the George Washington University, 1325 H Street, N. W., at 8 p.m.

Thursday, October 4: The Entomological Society.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editor by the thirteenth and the twenty-seventh day of each month.

CONTENTS

Original Papers

Page

Physics.—A two-stage mercury vapor pump. H. F. Stimson.............. 477

Physics.—Probe-wire measurements of anode fall of potential. John T. Tate and Paul D. Foote.. 482

Radiotelegraphy.—Notes on the audion. L. W. Austin.................. 487

References

Paleontology... 490
Botany... 490
Forestry... 492
Phytopathology... 492
Plant Physiology... 496
Genetics... 497
Ornithology.. 497

Vol. VII

No. 16

October 4, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This Journal, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The Journal is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the Journal.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. VII | OCTOBER 4, 1917 | No. 16

MINERALOGY.—*Minasragrite, a hydrous sulphate of vanadium.*

WALDEMAR T. SCHALLER, Geological Survey.

The blue efflorescence occurring on patronite at Minasragra, Peru, was found to be a sulphate of vanadium and was named after the locality. It occurs abundantly at Minasragra, according to Mr. D. F. Hewett,[1] and also is forming at the present time on many of the patronite specimens in museums. A large specimen of patronite in the United States National Museum had a considerable amount of the blue efflorescence on it and furnished the material for the present investigation.

In addition to the matrix minerals, such as patronite, quisqueite, and the nickelic pyrite, bravoite, the specimen shows as an efflorescence blue minasragrite, white tufts of prismatic crystals of morenosite, glassy green equidimensional crystals of melanterite, and clear bladed crystals of gypsum. All of the efflorescent minerals have clearly been derived from the oxidation and hydration of those forming the matrix.

No measurable crystals of minasragrite were observed, the mineral forming small mamillary masses and granular aggregates with drusy surfaces, generally distinct from the other sulphates but in places penetrated by masses of morenosite needles. Examined under the microscope, the minasragrite shows irregu-

[1] Personal communication. Abundant material, much purer than the original sample, has now been obtained and an analysis of this better material will be undertaken.

lar granular masses, indistinct short prisms, and rarely sharply defined units of a rhombic shape (angle about 78°). Some pieces break up into similar rhombs by cleavage, so that it may be that all the observed rhombs are cleavage pieces and not distinct crystals. From the general inclined extinction of all straight edges it is concluded that the mineral is monoclinic or triclinic.

TABLE 1

ANALYSIS OF MINASRAGRITE MIXED WITH IMPURITIES

	ANALYSIS	DISTRIBUTION				
		Minasragrite	Melanterite	Morenosite	Gypsum	Insoluble
V_2O_4	5.29	5.29				
FeO	0.97		0.97			
NiO	1.92			1.92		
CaO	0.46				0.46	
SO_3	10.92	7.12	1.08	2.06	0.66	
Insoluble	66.16					66.16
H_2O (by diff.)	14.28	9.06	1.68	3.24	0.30	
	100.00	21.47	3.73	7.22	1.42	66.16

TABLE 2

RECALCULATED ANALYSIS AND RATIOS OF MINASRAGRITE

	ANALYSIS	RATIOS	CALCULATED
V_2O_4	24.64	1.02 or 1 × 1.02	23.92
SO_3	33.17	2.86 or 3 × 0.95	34.58
H_2O	42.19	16.17 or 16 × 1.01	41.50
	100.00		100.00

The color of minasragrite is blue, the luster vitreous. The refractive indices are approximately as follows: $\alpha = 1.515$, $\beta = 1.525$, $\gamma = 1.545$. The pleochroism is strong: X = deep blue, Y = blue, Z = colorless. The mineral is optically negative.

Heated in a closed tube, minasragrite readily fuses and gives off water. It is very soluble in cold water. The sample scraped off for analysis necessarily contained all the minerals of the efflorescence, which were separated from the patronite by cold water. The water of the sample had to be expressed by differ-

ence, and the insoluble matter (mostly patronite) was air dried and not heated before weighing. The results of the analysis are given in table 1.

The analysis, with the insoluble matter and associated melanterite, morenosite, and gypsum deducted and recalculated to 100 per cent, is shown with the ratios in table 2.

The ratios yield the formula $V_2O_4 \cdot 3SO_3 \cdot 16H_2O$, which is interpreted as $(V_2O_2)H_2(SO_4)_3 \cdot 15H_2O$, minasragrite being a highly hydrated acid vanadyl sulphate. Quantitative determinations (by permanganate titrations) show that all of the vanadium in the mineral is in the tetravalent condition.

Several hydrates of acid vanadyl sulphate are known. The pentahydrate $(V_2O_2)H_2(SO_4)_3 \cdot 5H_2O$ is formed when the acid solution is evaporated on a water bath at about 90°, and it can be recrystallized from sulphuric acid at 100°. Lower hydrates are formed at higher temperatures.[2] It is therefore to be expected that at ordinary temperature a higher hydrate than the pentahydrate would form, and in minasragrite, formed at ordinary temperature, 15 molecules of water represent the extent of the hydration.

It is interesting to note that Gerland[3] reported a hydrate with 14 molecules of water, but later investigators have failed to find it. Possibly Gerland's 14-hydrate was identical with minasragrite.

[2] Koppel, J., and Behrendt, E. C. *Verbindungen des vierwertigen Vanadins.* Zeitschr. anorg. Chem., **35**: 154. 1903. Earlier references are cited by these authors. See also Gain, Gustave. *Sur quelques sulfates de vanadium tetravalent.* Comp. rend., **143**: 1154–1156. 1906.

[3] Gerland, B. W. *Ueber einige Verbindungen des Vanadins.* Ber. d. Chem. Gesellsch., **9**: 869. 1876.

ZOOLOGY.—*The interrelationships of the subfamilies and genera included in the crinoid family Antedonidae.*[1] AUSTIN H. CLARK, National Museum.

Recently in the pages of this Journal[2] I proposed a rearrangement of the species of Antedonidae, distributing them among forty genera, which in turn were grouped in seven subfamilies.

In the following keys the interrelationships of the subfamilies, and of the genera within each, are shown.

Family ANTEDONIDAE Norman (emended)

Key to the Subfamilies of the Family Antedonidae

Cirrus sockets arranged in definite columns on a conical or columnar, usually large, centrodorsal....................ZENOMETRINAE
Cirrus sockets arranged in transverse alternating rows, or irregularly, on a hemispherical to discoidal or conical centrodorsal.
  The segments of the genital pinnules are much expanded, forming a roof over the gonads....................ISOMETRINAE
  The segments of the genital pinnules are not expanded.
    P_1 is composed of numerous (usually more than 50 and never less than 30) short segments of which at least the first six or seven, and usually nearly all, are broader than long, and the distal are rarely more than twice as long as broad; P_1 is about as long as, or longer than, P_2.
      One or more of the following pinnules resembles P_1. HELIOMETRINAE
      P_2 and the following pinnules are composed of segments which, beyond the third or fourth, are much elongated....................THYSANOMETRINAE
    P_1 is composed for the most part of much elongated segments, though a few of the basal segments may be short; the distal segments are at least twice as long as broad.
      The distal cirrus segments are entirely without dorsal processes on their distal ends; the cirri are usually (but not always) short, rarely with more than 20, never with more than 30, segments..ANTEDONINAE
      The distal cirrus segments always have the distal dorsal edge prominent, with the median portion more or less produced in the form of a dorsal spine, and the mid-dorsal line more or less strongly carinate.

[1] Published with the permission of the Secretary of the Smithsonian Institution.
[2] Journ. Wash. Acad. Sci., **7**: 127–131. 1917.

P_2 resembles P_1, and always differs from the genital pinnules; P_a is frequently, and P_1 occasionally, absent.................PEROMETRINAE

P_2 resembles P_3 and the succeeding pinnules, and often bears a more or less developed gonad; all of the lower pinnules are invariably present...................BATHYMETRINAE

Subfamily ANTEDONINAE A. H. Clark

Key to the Genera of the Subfamily Antedoninae

P_2 of the same length and character as P_3 and the following pinnules, and much shorter than (usually about half as long as) P_1.

Pinnule segments with unmodified, or at the most with very finely spinous, distal edges; size medium, the arms rarely under 45 mm. in length (*Norway to the Gulf of Guinea, including the entire Mediterranean basin and the east Atlantic Islands; Caribbean Sea to Rio de Janeiro, Brazil;* 0–445 *meters*).......................................**Antedon**

Pinnule segments with strongly produced, everted and coarsely spinous distal edges; size small, the arms never over 70 mm. and rarely over 45 mm. in length (*Southern coasts of Australia northward throughout the East Indian region to southern Japan;* 0–275 *meters*)..............**Compsometra**

P_2 not of the same length and character as P_3 and the following pinnules, and never only half as long as P_1.

P_3 of the same length and character as the succeeding pinnules.

Centrodorsal flattened hemispherical or discoidal; size medium, the arms being between 60 mm. and 120 mm. in length; P_1 has 18–40 segments.

P_1 longer than the cirri, becoming very slender and flagellate distally, composed of about 40 segments (*Ceylon to the Society Islands;* 0–47 *meters*) **Mastigometra**

P_1 shorter than the cirri, less slender and more or less stiffened, composed of 18–21 segments (*Moluccas to China, and eastward to the Society Islands;* 0–397 *meters*)............................**Euantedon**

Centrodorsal conical; size small, the arms being about 30 mm. in length; P_1 and P_2 have 12–13 segments (*Hawaiian Islands and northern New Zealand;* 108–293 *meters*)...............................**Argyrometra**

P_3 not of the same length and character as the following pinnules.

P_3 much the longest and stoutest pinnule on the arm.

The distal ends of the cirrus segments do not overlap the bases of those succeeding; the dorsal edge of the outer four to six cirrus segments is about as long as the proximal border; the brachials have

strongly produced and coarsely spinous distal edges (*Flores to Borneo and the Philippine Islands; 0–502 meters*) .... **Toxometra**

The cirrus segments have produced distal ends which overlap the proximal ends of those succeeding; the outer cirrus segments are much longer than their proximal width; the brachials have smooth, or only very finely spinous, distal edges.

Smaller, with not over 16 cirrus segments; cirri less numerous, XX–XLV (rarely over XL); arms 23 mm. to 50 mm. long (*From the Red Sea to Madagascar and Mauritius, eastward to northern Australia and the East Indies, and northward to southern Japan; 0–106 meters*) **Dorometra**

Larger, with 16–33 cirrus segments; cirri more numerous, XXXV–LX (rarely less than XL); arms 75 mm. to 80 mm. long (*Lesser Sunda Islands to the Philippines; 69–140 meters*) **Eumetra**

P_3 not much the longest and stoutest pinnule on the arm.

P_1, P_2, and P_3 similar and of approximately equal length, with at least 13 segments.

P_1, P_2, and P_3 longer than the genital pinnules; the pinnules are not especially stiffened, and their component segments do not bear prominent spines on the distal edges; the centrodorsal is low hemispherical (*Philippine Islands to southern Japan; 23–192 [?250] meters*) **Iridometra**

P_1, P_2, and P_3 shorter than the genital pinnules; all the pinnules slender and stiff, especially the lower which are thorn-like with long spines on the distal edges of the segments; the centrodorsal is large, rounded conical (*Coast of Brazil; 41 meters*)....... **Hybometra**

P_2 much longer than P_1, and longer than P_3, though similar to the latter; centrodorsal more or less sharply conical (*Andaman Islands to southern Japan; 54–201 [?250] meters*) .... **Andrometra**

Subfamily THYSANOMETRINAE A. H. Clark

Key to the Genera of the Subfamily Thysanometrinae

P_2 with the third segment as long as, or longer than, broad, and the following segments markedly longer than broad (*Southern Japan and the Admiralty Islands; 126–355 meters*) .... **Thysanometra**

P_2 with the third segment broader than long, and the fourth broader than long, or about as long as broad (*Caribbean Sea, and northward to North Carolina;* 13–1029 *meters*) .... **Coccometra**

Subfamily PEROMETRINAE A. H. Clark

Key to the Genera of the Subfamily Perometrinae

P_1 and P_a absent; size small, the 10 arms being from 25 mm. to 35 mm. (usually between 25 mm. and 30 mm.) in length; cirri XX–XXX, 22–25, 10 mm. long (*West Indies;* 59–433 *meters*) **Hypalometra**

P_1 always present, though P_a (on the inner distal end of the first syzygial pair) is sometimes absent.

Ossicles of the IBr series and first two brachials with smooth and unmodified depressed borders, laterally in close apposition with their neighbors and sharply flattened against them; synarthrial tubercles (on the articulations between the elements of the IBr series and first two brachials) very prominent, sometimes extravagantly developed; P_1 is as long as, longer than, or shorter than, P_2; P_a may be absent; 10–14 (usually 10) arms from 35 mm. to 90 mm. long 28–55 cirrus segments (*From Madagascar to the Kei Islands and southern Japan;* 70–252 [?273] *meters*) .... **Perometra**

The ossicles of the IBr series and first two brachials may be just in contact laterally, but their sides are never sharply flattened, and prominent synarthrial tubercles are never developed; their lateral borders always bear tubercles, one or many to each ossicle, and their distal and proximal borders are usually prominently everted and tubercular.

Interbrachial portions of the perisome naked; P_a always present (*Kei Islands and southern Japan;* 204–344 *meters*) **Nanometra**

Interbrachial portions of the perisome with numerous prominent rounded calcareous nodules which are not in lateral contact; P_a usually absent (*Moluccas and southern Japan;* 99–270 *meters*) .... **Erythrometra**

Subfamily HELIOMETRINAE A. H. Clark

Key to the Genera of the Subfamily Heliometrinae

10 radials and 20 arms (*coasts of the Antarctic continent, and Kerguelen Island;* 18–400 *meters*) .... **Promachocrinus**

5 radials and 10 arms.

Each brachial bears a high median carinate process; P_1 much longer than P_2 (*Coasts of the Antarctic Continent;* 223–400 [?900] *meters*) .... **Anthometra**

No carinate processes on the brachials.

Brachials very short, much broader than long; middle and

distal pinnules with very short segments which are rarely longer than broad; cirrus segments very short, only very few, or none at all, longer than broad; P_1 and P_2 of approximately the same length (*Vicinity of Heard Island, and the winter quarters of the "Discovery;"* 135–270 *meters*) .... **Solanometra**

Brachials longer, about as long as broad or slightly longer than broad; segments of the middle and distal pinnules longer than broad, usually very much so; a number of the earlier cirrus segments longer than broad.

P_1 with 30–45 segments of which those beyond the seventh to eleventh are longer than broad, the distal elongate, though never much more than twice as long as broad; P_2 is similar to P_1, but shorter (*Arabian Sea to southwestern Japan;* 192–2160 *meters*) .... **Cyclometra**

P_1 with 50–100 segments of which only the terminal are longer than broad, and those only very slightly so; P_2 is similar to P_1, and usually of about the same length.

Brachials with smooth distal edges; ossicles of the division series with smooth borders and a smooth dorsal surface; no rudimentary terminal comb on the proximal pinnules (*Arctic Ocean, and southward to Norway and Nova Scotia; western shores of the Okhotsk and Japanese Seas from Cape Terpenia to Korea;* 12–1340 *meters*) .... **Heliometra**

Brachials with spinous distal edges; ossicles of the division series with usually spinous borders and commonly with a greater or lesser development of spines on the dorsal surface; the proximal pinnules bear a rudimentary terminal comb suggesting that found in the species of the Comasteridae (*From Cape Horn northward along the western coast of South and North America to Alaska, thence westward and southward to southern Japan;* 11–1911 *meters*). **Florometra**

The genus *Heliometra* includes only the well known *Heliometra glacialis* (Leach) (= *Antedon eschrichti* [J. Müller] of P. H. Carpenter and earlier authors generally).

Anthometra, *Solanometra*, and *Florometra* are best considered as subgenera of *Promachocrinus*. A full account of the first two

and the last will be found in my memoir on Die Crinoiden der Antarktis.[3]

Subfamily ZENOMETRINAE A. H. Clark

Key to the Genera of the Subfamily Zenometrinae

P_1 and P_a absent (*Philippine Islands;* 140–148 *meters*)..... **Balanometra**

P_1 and P_a present.

Cirri with all the segments elongated, the distal entirely without dorsal processes; or (very rarely) a few of the outermost cirrus segments may be but little longer than broad with slight dorsal tubercles.

Cirrus sockets arranged in closely crowded columns in each radial area; but the groups of columns in each radial area are usually (almost invariably) separated from the groups of columns in the adjacent radial areas by long triangular bare patches; the distal cirrus segments are always greatly elongated, never with any trace of dorsal processes (*From the Galápagos Islands and Panama northward to the Aleutian Islands, and southward on the Asiatic coast to Yezo Strait and the northern part of the Sea of Japan; the Hawaiian Islands; the Philippine Islands; the Lesser Sunda Islands; the Bay of Bengal and the coast of Travancore, and southward to the Antarctic regions;* 336–2858 *meters*) **Psathyrometra**

Columns of cirrus sockets somewhat irregular, and evenly spaced all around the centrodorsal without differentiation into radial groups; the distal cirrus segments may be much elongated with no trace of dorsal processes, or little, if any, longer than broad, with slight dorsal tubercles (*From the western coast of Scotland, and Ireland, southward to Madeira, including the entire Mediterranean basin;* 45–1292 *meters*) .... **Leptometra**

Cirri with the proximal segments more or less elongated, but the distal segments short, never longer than broad, and bearing prominent dorsal processes.

Division series and arm bases smooth; 10–14 arms (*Kei Islands and northern Cuba;* 252–380 *meters*) **Adelometra**

Division series and arm bases spiny.

Size large; cirri with more than 40 (50–60 segments; columns of cirrus sockets very regular, separated interradially by high ridges, or by broad bare areas.

Two columns of cirrus sockets in each radial area,

[3] Deutsche Südpolar-Expedition, **16** (Zoologie, **8**), May 16, 1915, pp. 120–143.

the radial areas being separated by high ridges (*From St. Lucia, British West Indies, northward to Georgia and Pensacola, Florida; 304–792 meters*) .... **Zenometra**

Three columns of cirrus sockets in each radial area, the radial areas being separated by broad bare areas (*Hawaiian Islands; 346–633 meters*). **Sarametra**

Size small; cirri with less than 30 segments; columns of cirrus sockets on the centrodorsal slightly irregular; interradial areas on the centrodorsal not especially differentiated (*Marion Island, and the shores of the Antarctic continent in the vicinity of Gaussberg; 252–400 meters*) .... **Eumorphometra**

Subfamily ISOMETRINAE A. H. Clark

The only genus in this subfamily is *Isometra*, of which a complete account will be found in *Die Crinoiden der Antarktis*, pp. 145–146.[4]

Subfamily BATHYMETRINAE A. H. Clark

Key to the Genera of the Subfamily Bathymetrinae

All the cirrus segments short, the longest not so much as twice as long as the median diameter.

Cirrus segments cylindrical, without expanded distal ends, 25–33 (usually nearer the latter) in number, the longest (third-fifth) about one-third again as long as broad, those beyond the eighth about as long as broad, the distal slightly broader than long; IBr series and arm bases without lateral processes, and widely free laterally (*Western coast of Ireland; 698 meters*) .... **Orthometra**

Cirrus segments with much swollen distal ends, not more than 20 in number; IBr series and brachials in close lateral contact (*Moluccas to Marion Island, southeast of Africa; 1089–2880 meters*) .... **Tonrometra**

Proximal cirrus segments elongated, at least twice as long as the median diameter, and usually much longer.

Centrodorsal sharply conical with straight sides, nearly or quite as long as broad at the base (*Philippine Islands to Celébes; 509–1901 meters*) .... **Fariometra**

Centrodorsal less sharply conical, with rounded sides, or hemispherical, and lower.

All the brachials have strongly produced and very spinous edges; P_1 very slender and delicate, markedly longer than P_2, with the outer segments very greatly elon-

[4] Deutsche Südpolar-Expedition, **16** (Zoologie, **8**), May 16, 1915.

gated with overlapping and spinous distal ends (*From southern Japan, the Hawaiian and Philippine Islands westward to Cape Comorin, thence southwestward to between Marion Island and the Crozets; from the Bay of Biscay northward to 54° 17′ N. lat., and from Brazil northward to the Newfoundland banks;* 248–2926 *meters*) **Trichometra**

The brachials do not have strongly produced and very spinous distal ends; at most the distal edges of the outer brachials are bordered with fine spines.

P_1 much elongated, between two and three times as long as P_2, composed of 30–40 segments of which a few of the basal are short, the following becoming slender and greatly elongated (*Arctic Ocean from western Greenland to the Kara Sea, and southward to Portugal and Chesapeake Bay, and also in the vicinity of Marion Island, southeast of South Africa;* 18–1800 *meters*) .... **Hathrometra**

P_1 the same length as, longer than, or shorter than, P_2; but if longer never more than slightly so, and with not more than 20 segments.

Cirri with 20–30 relatively short segments of which the last six to thirteen are only very slightly, if at all, longer than broad.

Pinnules not especially long; distal pinnules the same length as the proximal pinnules; P_2 resembling P_3 and the following pinnules, slightly longer and stouter than P_3 with somewhat fewer segments which are proportionately longer; P_2 may bear a gonad, though these usually begin on P_3; arms 25 mm. to 60 mm. long; cirri L-LX, 21–30 (*Kei and Meangis Islands, and southern Celébes;* 204–1158 *meters*) **Nepiometra**

Pinnules very long; distal pinnules not so long as the proximal pinnules; P_2 very slightly shorter than P_1, but similar to it, with about 18 elongated segments; following pinnules similar; arms about 20 mm. long; cirri about XXX, 20–25 (*Southeastern South America;* 1080 *meters*) **Phrixometra**

Cirri with not more than 20 much elongated segments all of which are markedly longer than broad, especially the proximal.

More than XXV cirri, which have 10–20 segments (*Eastern Pacific, including the Seas*

of Okhotsk and Japan, from western Bering Sea to the Kermadec Islands and New Zealand, and westward to between Marion Island and the Crozets; southwest of Iceland; 144–3178 *meters*) . . **Thaumatometra**

Not more than XV cirri, which have not more than 10 segments (*Abysses of the Pacific from west of Tasmania to west of Japan;* 4680–5220 *meters*) . . . . **Bathymetra**

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*The enrichment of ore deposits.* W. H. EMMONS. U. S. Geol. Survey Bull. 625. Pp. 530. 1917.

This report is an amplification of an earlier Survey bulletin on the enrichment of sulphide ores (Bulletin 529). Fifteen elements and their compounds not considered in the earlier report are discussed with reference to their reactions in the zone of oxidation. All recent important advances in the subject have been incorporated and the general treatment has been considerably broadened.

The geologic conditions favorable and unfavorable to the formation of enriched mineral deposits are described and the criteria by which such deposits may be recognized are outlined. The natural chemical processes by which enrichment is produced are fully discussed and the behavior of each metal is considered separately and is illustrated by descriptions of many of its known valuable enriched ore bodies. A. K.

GEOLOGY.—*Notes on the greensand deposits of the eastern United States.* GEORGE H. ASHLEY. U. S. Geol. Survey Bull. 660-B. Pp. 27–58. 1917.

No attempt was made at a detailed survey of the greensands but samples were collected from the most accessible of the deposits and analyzed to determine their percentage of potash. The results of the study show that the richest and largest deposits of greensand occur in New Jersey, extending down into Delaware. Lower grade greensands occur abundantly in Maryland and less abundantly in Virginia, North Carolina, Arkansas, Texas, and doubtless the other Southern States.

The richest deposits show a potash content around 7 per cent,

which is close to the percentage of potash in glauconite, of which the best greensands are almost entirely made up. These greensands occur in the basal part of the Cretaceous formation of New Jersey and Delaware and in the upper part of the Eocene. Those of New Jersey are entirely in the Cretaceous, while those of Maryland are in both Cretaceous and Eocene.

The paper also contains a contribution on *Methods of analysis of greensands* by William B. Hicks and Reginald K. Bailey, discussing the methods used in making these analyses, which differ somewhat from methods previously used. G. H. A.

GEOLOGY.—*The Irvine oil field, Estill County, Kentucky.* Eugene W. Shaw. U. S. Geol. Survey Bull. 661-D. Pp. 141–191. 1917.

The report outlines the history of the Irvine oil field, which in three years has developed into the richest oil territory in the state, and describes the geology, including the nature and lay of the rocks, the character and occurrence of the oil, and other features of the field. The report contains one map, 20 by 30 inches, showing the structural geology, farm lines, wells, and other features on a scale of 2 miles to the inch, and another map showing the general geologic structure of about 1000 square miles surrounding the field on a scale of 4 miles to the inch.

The Irvine oil field is by far the most productive yet developed in Kentucky. In fact, its output in 1917 will be more than twice as great as that of the dozens of other oil fields in the State, some of them long productive; and it will probably produce much more in 1918. The field is in a region where oil showings have long been known and oil has long been sought, and yet somehow this great pool 10 miles long and 2 miles wide was missed. The west side of the Irvine field is within a mile of outcrops of the oil-bearing bed, which may be seen at several places in and around Irvine. Some of the wells are less than 100 feet deep and yet furnish good yields, even the oldest showing a relatively low rate of decline. E. W. S.

GEOLOGY.—*Geology and ore deposits of the Mackay region, Idaho.* Joseph B. Umpleby. U. S. Geol. Survey Prof. Paper 95. Pp. 129. 1917.

The Mackay region is in southeastern Idaho north of Snake River. It has yielded about $3,750,000, of which $2,300,000 has come from copper, and the remainder from silver, lead, and gold.

The older formations of the region comprise more than 20,000 feet of strata ranging in age from Algonkian to Pennsylvanian. These rocks were intruded by large masses of granite in late Cretaceous or early Eocene time. Great volumes of andesite lava flooded a system of deep valleys in Miocene time, and extensive outpourings of basalt during the Pliocene have covered parts of the region.

The principal ore bodies are contact-metamorphic copper deposits. They are of particular scientific interest because they appear to have been formed by gaseous transfer from a granite magma, during which large quantities of iron, aluminum, silicon, copper, and sulphur were supplied to the contact rocks. The geologic relations are unusually favorable and allow almost rigorous proof that the ore-depositing solutions were of magmatic origin. The copper deposits are highly oxidized, and chrysocolla is the main constituent. Many of the features of the oxidized ores appear to be of colloidal origin, and the prevalent microscopic banding is probably due to rhythmic precipitation in gelatinous media (the Liesegang effect). A. K.

GEOLOGY.—*The Newington moraine, Maine, New Hampshire, and Massachusetts.* FRANK J. KATZ and ARTHUR KEITH. U. S. Geol. Survey Prof. Paper 108-B. Pp. 11–29. 1917.

A recessional moraine consisting of several separate segments disposed along a sinuous course lies near the Atlantic coast and has been traced through 60 miles from Saco, Maine, to Newbury, Massachusetts. It is for the most part about or less than 100 feet above sea level but rises to 180 feet in Biddeford, Maine, 150 feet in Dover, New Hampshire, and Newburyport, Massachusetts, and is between 200 and 250 feet above the sea in Wells and South Berwick, Maine. Although not more than 40 to 100 feet higher than surrounding Pleistocene formations, nevertheless it is topographically prominent because it is in a region of slight relief. The moraine rests upon and is surrounded by a floor of ice-smoothed rock and of till. The region was submerged during the building of the moraine, and the ice front stood in the sea. The moraine is the result of the accumulation of glaciofluvial detritus discharged directly into the sea; consequently in some places it is built up as broad, flat, delta-like plains of sand and gravel. Clay ("Leda clay") was continuously deposited in the sea, both while the moraine was accumulating and after the ice retreated from the moraine, so that the younger clay beds in some places overlie the

moraine. This clay is the fine glacial outwash. The moraine and the marine clay probably belong to a late Wisconsin substage of the Pleistocene epoch. F. J. K.

BOTANY.—*Grasses of the West Indies*. A. S. Hitchcock and Agnes Chase. Contributions from the U. S. National Herbarium, **18**: 261–471. 1917.

The paper is a descriptive list of 110 genera and 455 species of the grasses of the West Indies. For the purposes of the list the West Indies includes Bermuda, the Bahamas, Trinidad, and Tobago but excludes the Dutch Islands off the coast of Venezuela. There are keys to the tribes and genera and keys to the species of each genus. The genera and species are briefly described and under each species is given full synonymy, the habitat, geographical range, the common names, and the locality from which the species and the synonyms were described (the type localities). An attempt has been made to account for all the species credited to the West Indies. One genus and 14 species are described as new. Appended to this list is a catalogue of all the specimens in the U. S. National Herbarium, arranged by collectors' names and numbers. A. S. H.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, October 6: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, October 10: The Medical Society, at the Medical Department of George Washington University, 1325 H Street, N. W., at 8 p.m.

Thursday, October 11: The Chemical Society, at the Cosmos Club, at 8 p.m.

Saturday, October 13: The Philosophical Society, at the Cosmos Club, at 8:15 p.m. Program:

R. A. Millikan (by invitation): *The organization of scientific effort in relation to the war.* 30 minutes.

G. K. Burgess: *The application of science to warfare in France.* 30 minutes.

Tuesday, October 16: The Anthropological Society, at the National Museum, rooms 42-43, at 4:30 p.m. Program:

Mitchell Carroll: *The story of Greece.*

Tuesday, October 16: The Society of Engineers, at Rauscher's, 1034 Connecticut Avenue, at 8 p.m.

Wednesday, October 17: The Medical Society, at the Medical Department of George Washington University, 1325 H Street, N. W., at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editor by the thirteenth and the twenty-seventh day of each month.

CONTENTS

ORIGINAL PAPERS

Page

Mineralogy.—Minasragrite, a hydrous sulphate of vanadium. WALDEMAR T. SCHALLER 501

Zoology.—The interrelationships of the subfamilies and genera included in the crinoid family Antedonidae. AUSTIN H. CLARK 504

ABSTRACTS

Geology 513

Botany 516

Vol. VII No. 17

October 19, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. VII OCTOBER 19, 1917 No. 17

PHYSICS.—*The resonance and ionization potentials for electrons in sodium vapor.* JOHN T. TATE and PAUL D. FOOTE, Bureau of Standards.

When electrons are accelerated through mercury or cadmium vapor two distinct types of inelastic impact have been observed to take place. The first of these occurs at the experimentally observed potentials of 4.90 volts for mercury[1] and 3.88 volts for cadmium[2] and is accompanied by the radiation of light of a single wave length, 2536.72 Å for mercury[3] and 3260.17 Å for cadmium.[4] This radiation is not the result of a recombination with the atom of an electron removed by the impact but is to be regarded as due to an agitation of the electrons bound in the atom.[5] The large transfer of energy from the moving electron to the atom may be explained if we assume that at these critical velocities the time of interaction between electron and atom bears a simple relation to the natural period of vibration of one of the electrons bound in the atom. Under these conditions the electron may be said to have a resonance velocity characteristic of the vapor through which it is moving. The resonance velocity may be calculated theoretically[6] from the frequency, ν, of the radiation emitted, by making use of the relation

$$h\nu = eV$$

where h is Planck's element of action (here assumed to be

[1] FRANCK and HERTZ. Verh. d. D. Phys. Ges., **16**: 457–467. 1914.

[2] TATE and FOOTE. Bull. Bur. Stds. (In press.)

[3] FRANCK and HERTZ. Verh. d. D. Phys. Ges., **16**: 512–517. 1914.

[4] MCLENNAN and HENDERSON. Proc. Roy. Soc. Lond., **91**: 485–491. 1915.

[5] TATE. Phys. Rev, **7**: 686–687. 1916. TATE and FOOTE. Idem, **10**: 81. 1917.

[6] MCLENNAN and HENDERSON. Loc. cit.

6.56×10^{-27} erg sec.),[7] e the electronic charge, and V the potential necessary to give the electrons the resonating velocity. The

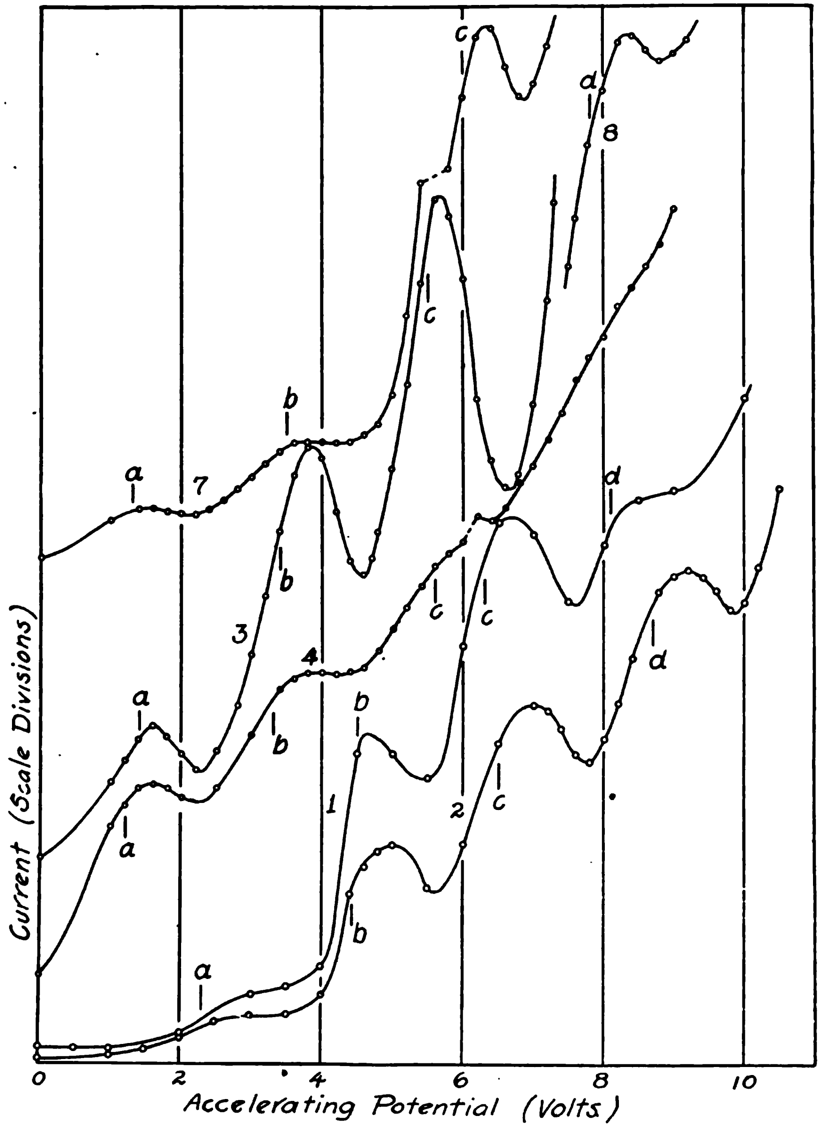

Fig. 1. Variation with accelerating potential of current to outside cylinder.

[7] Coblentz. Bull. Bur. Stds., **13**: 470. 1916.

values obtained for V on this basis are 4.88 volts for mercury and 3.79 volts for cadmium.

The second type of inelastic impact has been observed at 10.3[8] or 10.4 volts[9] for mercury and 8.92 volts[10] for cadmium. Collisions taking place at these potentials are characterized by the complete removal from the atom of one or more bound electrons, i.e., by ionization of the atom,[11] and by the emission of the complete spectrum of the vapor.[12] We may, following

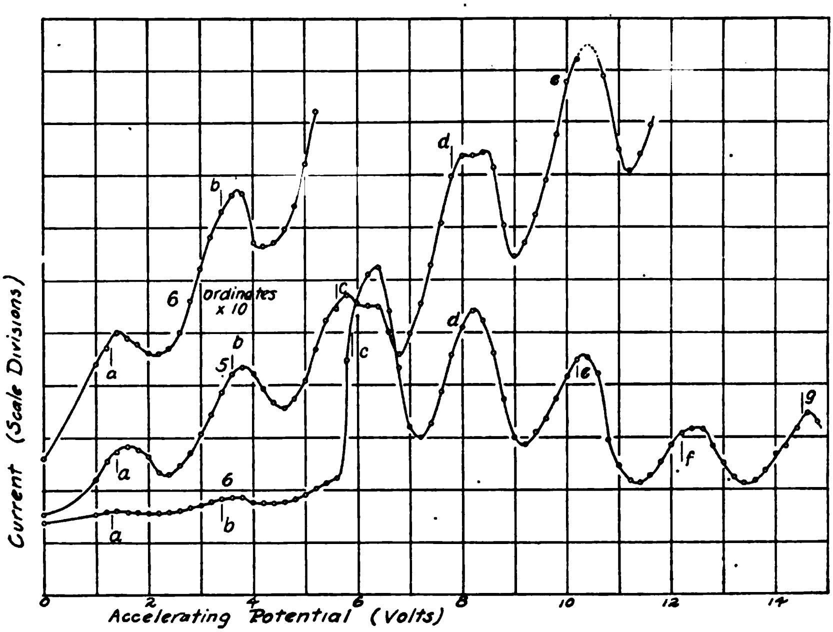

Fig. 2. Variation with accelerating potential of current to outside cylinder.

McLennan, calculate the ionizing potential on the basis of Bohr's theory of atomic structure from the limiting frequency ν = (1.5, S) in the spectra of these metals and obtain for mercury 10.41 volts and for cadmium 8.97 volts. The agreement between observed and calculated values of both resonance and

[8] Tate. Loc. cit.
[9] Davis and Gaucher. Phys. Rev., **10**: 101. 1917.
[10] Tate and Foote. Loc. cit.
[11] Tate. Loc. cit.; Tate and Foote. Loc. cit.
[12] McLennan and Henderson. Loc. cit.

ionization potentials is well within the limits of experimental error.

The object of the present investigation is the experimental determination of the critical potentials for electrons in sodium vapor. The experimental arrangement was identical with that used by the writers in the work on cadmium vapor and the method of measurement that already described for the determination of critical potentials in mercury vapor.

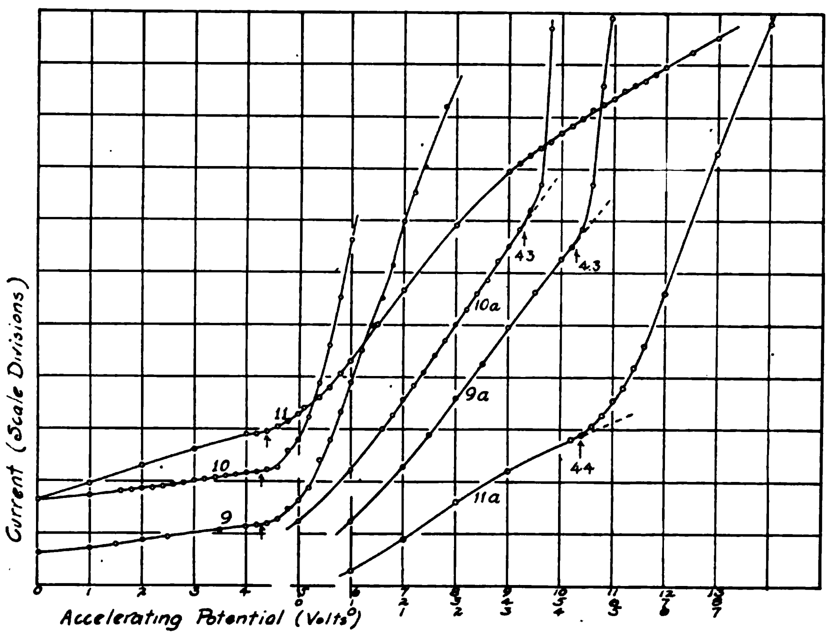

Fig. 3. Variation with accelerating potential of total current from hot wire. Upper abscissae values apply to curves 9, 10, 11; middle values to curve 10 a; and lower values to curves 9 a and 11 a.

The results of the present work are represented graphically by figures 1, 2, and 3. Curves 1 to 8, figures 1 and 2, show the variation with the accelerating potential between hot wire and gauze of that portion of the current which reaches the outside cylinder against a retarding field of about 0.8 or 0.9 volts. The sudden falling off in the rate of increase of current which takes place at the points a, b, c, d, etc., indicates that at the effective potentials of these points inelastic impact has taken place.

The correct value for the critical potential is obtained by taking the difference in potential between successive points, thus eliminating any effect of initial velocity. For reasons to be discussed later only the points *a* and *b* were used. The average value obtained for the difference in potential between *a* and *b* on curves 3 to 7 was 2.12 volts. Curves 1 and 2 were preliminary curves and not enough points were observed to permit of an accurate determination of the critical potentials.

TABLE 1

SUMMARY OF DATA ON SODIUM

	APPLIED POTENTIALS AT RESONANCE							RESONANCE POTENTIAL	INITIAL POTENTIAL
Curve	a	b	c	d	e	f	g	b–a	
1	2.3	4.5	6.3	8.1					
2	2.3	4.5	6.5	8.7					
3	1.4	3.4	5.5					2.0	0.6
4	1.2	3.3	5.6					2.1	0.9
5	1.4	3.6	5.6	7.8	10.0			2.2	0.8
6	1.3	3.4	5.9	8.0	10.2	12.2	14.5	2.1	0.8
7	1.3	3.5	6.0					2.2	0.9
8				7.8					
							Mean	2.12 ±0.06	0.80
9a	4.3 Applied potential for ionization.								
10a	4.3 Applied potential for ionization.								
11a	4.4 Applied potential for ionization.								
	4.33 Mean applied potential.								
	0.80 Initial potential.								
	5.13 Ionization potential.								

The initial velocity of the electrons may be obtained from these curves directly. For example, in curve 6, the first resonance occurs at 1.3 volts and the second at 3.4 volts. The correct resonance potential is the difference of these two values or 2.1 volts. Hence the first resonance must have occurred at a true potential of 2.1 volts. The initial potential is the correction necessary to add to the applied potential of 1.3 volts to give

this value, viz. 0.8 volts. The mean value thus obtained for curves 3 to 7 was 0.80 volts.

Without changing conditions in any way the curves 9, 10, and 11, figure 3, representing the variation in total current from the hot wire with accelerating potential were obtained. Curves 9 *a*, 10 *a*, and 11 *a* are sections of the curves 9, 10, and 11 plotted on the same scale of coordinates used in figures 2 and 3. It is to be noted that there is no sudden change in the total current at points corresponding to *a* and *b*, etc., on the other curves. This indicates that no ionization results from the inelastic impact which occurs at 2.12 volts. There is, however, a sharp increase in current at an average applied potential of 4.33 volts. Correcting for the initial velocity as determined above gives 5.13 volts for the average value of the ionizing potential.

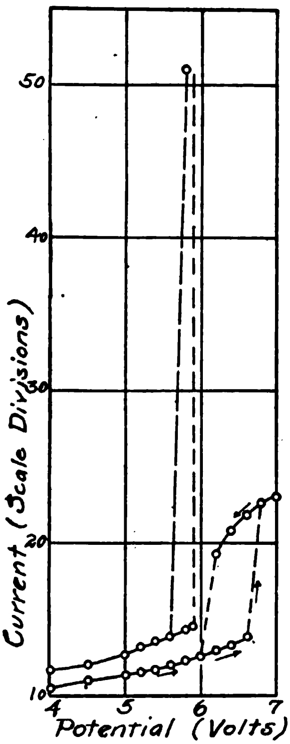

Fig. 4. Examples of discontinuous "total current" curves.

Simultaneously with the rapid increase in current at 4.33 volts there appeared a bright yellow glow about the hot wire.

It is to be emphasized that the critical points were chosen by plotting all curves on the same scale and estimating where the actual curves deviated by a constant predetermined small amount from the curve extrapolated beyond the critical point. Since we are dealing here with differences between similarly chosen points the element of arbitrariness in their choice is largely eliminated. The final results are tabulated in table 1.

With a rather high vapor pressure of sodium the total current curves showed a discontinuous break (see fig. 4) at some indeterminate potential. The current jumped to a very high value and, as the potential was decreased, remained very large until the potential was considerably lower than that at which the

sudden increase had taken place. It would then drop back, again discontinuously, to its original low value. Similar effects have been observed in mercury vapor. Continuous curves were obtained by decreasing the vapor pressure of the sodium.

The points of higher order *c*, *d*, *e* of curves 1 to 8 are of interest in that they are a combination of two overlapping effects. After ionization has set in at an observed potential of 4.33 volts it is to be expected that the electrons which start at this point will collide inelastically at potentials of 6.45, 8.57 volts, etc., whereas the electrons which had not been involved in an ionization would collide inelastically at 5.56, 7.68, etc. What is actually observed is a combination of the point 5.56 with 6.45, etc. (see especially curve 5 which shows distinct double maxima in these regions). On account of this overlapping no use was made of these points of higher order in the determination of critical potentials.

If, on the basis of Bohr's theory, we calculate the minimum wave length to be expected assuming a critical potential of 2.12 volts, we get $\lambda = 5830$ Å and it seems obvious that we are dealing here with the potential necessary to bring out the *D* lines. Using $\lambda = 5893$ Å we find for the critical potential necessary to excite the *D* lines 2.10 volts.

The minimum wave length corresponding to the observed ionizing potential is 2410 Å. The limiting wave length of the principle series of the sodium spectrum is 2412.63 Å.[13]

Summary.—(1) Electrons having a velocity corresponding to 2.12 ± 0.06 volts collide inelastically, without ionization, with the atoms of sodium vapor. The energy lost by the colliding electrons is probably radiated in light of wave lengths corresponding to the *D* lines. Assuming this to be the case the theoretical value of the resonance potential is 2.10 volts.

(2) Electrons having a velocity corresponding to 5.13 ± 0.10 volts are able to ionize sodium vapor and cause it to emit a brilliant yellow light. The theoretical value of the ionizing potential using the limiting wave length of the principal series in the sodium spectrum is 5.13 volts.

[13] Wood and Fortrat. Astrophys. Journ., 43: 73. 1916.

(3) The experimental results of the present paper afford another instance of the fundamental correctness of deductions based upon Bohr's theory of atomic structures.

In a very interesting paper[14] which has appeared since this paper was written, Wood and Okano observe an emission of the *D* lines at a potential of 0.5 volts, and the appearance of the subordinate series (probably indicating ionization of the sodium vapor) at 2.3 volts. These values are much lower than those to be expected from the results of the present paper. It will be remembered that Hebb[15] has observed correspondingly low values for the potentials necessary to excite the single-lined and many-lined spectrum of mercury. The writers have observed a similar phenomenon in connection with a determination, which has just been completed, of the critical potentials for electrons in potassium vapor. It was found that the first resonance collision occurred at an effective applied potential of 0.2 volt (correcting for the potential drop along the hot wire). In all cases, however, the second resonance collision took place at a potential 1.60 volts higher than the first. This value (1.60 volts) is exactly that required, on the basis of Bohr's theory, to produce an emission of the fundamental lines ($\lambda = 7701.92$ Å and $\lambda = 7668.54$ Å) of the principal series of the potassium spectrum. Ionization of the potassium vapor was observed to take place at a potential roughly one volt higher than the second inelastic collision, i.e., at an effective potential of 3.2 volts + 1 volt, or 4.2 volts approximately. The theoretical value using the limiting frequency of the principal series of potassium is 4.33 volts.

It appears evident, therefore, that the electrons involved in producing these effects have initial velocities of about 1.4 volts—a value much greater than that to be expected. The reason for these high initial velocities is difficult to find. The presence of vapor or of a lime coating on the cathode seems necessary for their production, and it is not impossible that chemical forces

[14] WOOD and OKANO. Phil. Mag., **34**: 177. 1917.
[15] HEBB. Phys. Rev., **9**: 371. 1917.

are involved. It is suggested that a study of the relationship between the intensity of light emitted and the applied potential would prove of value as a spectroscopic determination of critical potentials.

PHYSICS.—*The photoelectric sensitivity of various substances.*[1] W. W. Coblentz and W. B. Emerson, Bureau of Standards.

Some time ago an examination was made of various substances to determine their electrical sensitivity to light; and in view of the fact that some of the results obtained are at variance with the measurements made by Case,[2] it seems desirable to publish a summary of our observations.

Two of the herein described substances were examined for change in electrical conductivity caused by the action of light upon them, and all of them were examined for photoelectrical activity when they were charged to a negative potential in an evacuated bulb and exposed to light.

When the substances were examined for an increase in electrical conductivity, a potential of 2 to 6 volts was connected through a resistance of zero to 100,000 ohms into a circuit containing a d'Arsonval galvanometer and the substance under investigation. In most cases the substances were slightly conducting when not exposed to light, so that the "dark current" had to be annulled by joining a counter e.m.f. through a resistance of 10,000 ohms to the terminals of the galvanometer. This counter e.m.f. was obtained by shunting across a resistance of 100 ohms which was in series with a cell of 2 volts and a variable resistance of zero to 70,000 ohms.

The source of light, when not otherwise specified, was a 16-c.p. carbon incandescent lamp, placed at a distance of 10 cm. from the substance under investigation. One disappointing feature of this investigation is that no substance was found which is comparable in sensitivity with the potassium photoelectric cell and with the selenium cell.

[1] To be published in full in the Bulletin of the Bureau of Standards.
[2] Case. Phys. Rev., 9: 305. 1917.

SUBSTANCES EXAMINED

Gallium. The material examined was the highly purified metal prepared and supplied by Dr. H. S. Uhler. This metal was solid, thus differing from the impure material, which is a liquid. It was melted and solidified over a platinum wire sealed into a glass bulb, thus forming the negative electrode of a photoelectric cell from which the air was exhausted. The anode was a loop of platinum wire, situated at a distance of about 12 mm. above the gallium electrode.

A potential of 340 volts was applied to the cell which was connected to a sensitive iron-clad Thomson galvanometer ($i = 5 \times 10^{-10}$ amp.).

The results obtained proved disappointing, this metal being quite insensitive to light. When the cell was exposed to daylight the photoelectric current produced a deflection of only 4 to 5 mm., whereas similarly exposing a potassium photoelectric cell the photoelectric current was sufficient to give a deflection beyond the range of the scale.

Silver sulphide. The sample examined was a thin flexible strip, 6 by 10 mm. in area, prepared by Mr. G. W. Vinal.[3] In one test the silver sulphide formed the negative electrode of a photoelectric cell (evacuated glass bulb about 5 cm. diameter with a ring of platinum wire for the anode) similar to the gallium cell just described. It was connected through an iron-clad Thomson galvanometer to a battery of 340 volts. When exposed to daylight a deflection of perhaps 1 to 2 mm. was observed, but no deflection resulted from exposure to the standard carbon lamp.

In the second test, copper wires were melted to the ends of a strip (3 by 5 by 0.3 mm.) of silver sulphide which was connected in series with a high resistance, a storage cell of 2 volts, and a d'Arsonval galvanometer. When exposed to the standard lamp, the galvanometer deflection was 10 mm. In another sample about 2 cm. long, the ends joining the copper wires were covered to prevent thermoelectric currents. The exposed area

[3] VINAL. Bur. Standards Scientific Paper No. 310.

was 14 by 4 mm. The radiation from the standard lamp produced a deflection of 13 to 17 mm. Both samples were quick acting, and after exposure to light there was no lag such as obtains in selenium in recovering its dark resistance.

Selenium. A crystal of selenium, prepared by Dr. F. C. Brown[4] and having a receiving surface of less than one sq. mm., when exposed to the standard lamp gave a deflection of more than 50 cm., which shows its great sensitivity as compared with other substances.

The mounting of the selenium crystal consisted of metal electrodes between which the crystal was held by compression. When operated as a photophone, by connecting the selenium crystal with an audion amplifier as described on a subsequent page, a loud musical note was obtained.

Tellurium. This metal is said to change in resistance when exposed to light. The present tests were made upon a mirror of tellurium deposited upon a glass plate by cathode disintegration. Suitable terminals were attached to a sample about 4 by 50 mm. No change in conductivity was observed when it was exposed to light.

Boleite. The sample of boleite [3Pb Cl (OH) . Cu Cl (OH) + Ag Cl], from Boleo, Mexico, examined was a single rectangular crystal 3 by 3 by 1.5 mm. It was held by compression between copper electrodes. No change in conductivity was observed when the crystal was exposed to daylight or to the standard incandescent lamp.

Stibnite. Samples of this same specimen of stibnite, Sb_2S_3, were supplied to Elliot[5] for investigation. The purpose of the present investigation was to obtain a comparison of its sensitivity with that of other substances containing antimony.

The size of one sample examined was 4 by 7 by 0.5 mm. Terminals were attached to it by heating a copper wire to incandescence in a gas flame and bringing it in contact with the plate of stibnite.

The standard carbon lamp caused a deflection of 5 cm. Stib-

[4] Brown. Phys. Rev., (2) **4**: 85. 1914.
[5] Elliot. Phys. Rev., (2) **5**: 53. 1915.

nite may be considered as sensitive as boulangerite, to be mentioned presently, but the deflection drifted, due to the decrease in resistance with time already noticed by other observers.

Boulangerite. The specimen of boulangerite ($3PbS.Sb_2S_3$, Irkutsk, Siberia) investigated was obtained from the Smithsonian collection, No. 78395. Several samples were examined. In one sample, 4 by 7 by 0.8 mm., the electrodes consisted of copper wires melted into the material as just described. The radiation from the standard lamp gave a deflection of 10 to 20 cm.

Another sample, 1 by 1.2 by 2 mm., held by compression between two heavy electrodes of copper, when exposed to the standard incandescent lamp produced a deflection of 2 to 3 cm., which is comparable with the preceding when one considers the size of the exposed surfaces.

Although this substance seems fairly sensitive, it did not appear to be sufficiently so to justify an investigation of its spectral sensitivity with a view of using this mineral as a selective radiometer.

Jamesonite. ($2PbS.Sb_2S_3$; Smithsonian collection No. 12,500; from Cornwall, England.) The sample examined (size 2 by 7 by 1 mm.) had the copper wire terminals attached by fusing the incandescent wire into the material. The standard lamp gave a deflection of only 1 to 2 cm., which seems to indicate that this material is not so light-sensitive as is boulangerite.

Mixtures of galena, PbS, and stibnite, Sb_2S_3, in various proportions were melted in a crucible and poured upon a plate of metal. Several samples, 5 by 10 by 0.5 mm., were examined, but none of them gave any indication of light-sensitiveness (change in resistance) when exposed to daylight or to the standard incandescent lamp.

Bismuthinite. Bismuthinite, Bi_2S_3, was obtained from the Smithsonian collection, No. 85071, from Jefferson County, Montana. This is the most interesting substance examined, in view of the diverse results obtained and the explanation offered therefor.

The sample of bismuthinite examined consisted of a nonhomogeneous mass of acicular crystals, which was easily crushed

into numerous fine needle-like crystals. The first sample examined was a small mass of crystals (size 1 by 1 by 0.7 mm.) held by compression between two heavy electrodes of copper. When the crystal was exposed to the standard carbon lamp no change in conductivity could be detected with certainty.

A second sample, 3 by 6 by 1 mm., had the copper wire terminals attached by fusion, as already described. The e.m.f's applied were the same as for the preceding sample. When exposed to the standard lamp no change in conductivity was observed. These results being contradictory to those published by Case[6] who used a three stage audion amplifier to detect the change in conductivity of the crystals, the foregoing experiments were repeated in the manner described by him. For this purpose the light from an acetylene flame shining through a slit 2 by 10 mm. was focused upon the crystal by means of a triple achromatic lens, 6 cm. in diameter and 18 cm. focal length. The light was interrupted by means of a sectored disk having 15 openings and operated by means of an electric motor, the speed of which could be varied. The usual speed gave 240 interruptions per second. The crystal was connected to a three stage audion amplifier and telephone receiver. A crystal of selenium or a selenium cell produced a loud note, but the samples of boulangerite and jamesonite, which by previous tests were light-sensitive, did not give a musical sound in the telephone.

The sample of bismuthinite with electrodes sealed on produced no audible note when exposed to light.

At least a dozen samples of bismuthinite held by compression between heavy copper electrodes were examined in connection with the amplifier. Of this number only two samples appeared to be light-sensitive. One sample produced only a faint sound in the telephone receiver. The second sample produced a loud note in the telephone. The sound was the loudest when the crystal was exposed along the line of contact with the copper electrode. Covering the crystal with red glass did not reduce the loudness of the note very much, indicating that the effect is due to heating of the material. Unfortunately, this crystal was

[6] Loc. cit.

crushed while under investigation. Prolonged tests on other samples gave negative results as regards the production of sound.

In view of the fact that the tests made with a sensitive galvanometer failed to show an increase in conductivity when bismuthinite was exposed to light, it appears that the change in conductivity which was observed when a certain specimen was exposed to intermittent flashes of light (photophone or, rather, radiophone) is the result of a thermal change within the crystal, or perhaps a change in the contact resistance at the electrodes.[7] In this connection the following experiments on thin strips of metals are of interest.

Platinum and gold. In conclusion it is of interest to record the results obtained when using thin blackened strips of platinum and of gold-leaf as radiophones, by connecting them through a battery to an amplifier.

These blackened strips were warmed intermittently by exposing them through a rotating sectored disk to the acetylene flame, as already described.

When a sensitive platinum bolometer receiver was used as a radiophone, the sound produced in the telephone was not very audible. This no doubt was due to the great heat capacity of the material which prevented the rapid alternations in resistance, and hence in electric current, from being of sufficient magnitude to affect the telephone receiver.

Using a lightly smoked strip (6 by 2.5 mm.) of gold-leaf, the ends of which were clamped between thin (0.02 mm.) strips of tin, the sound produced in the telephone receiver was as loud as was observed in the photophone made of selenium.

This device was mounted in a glass bulb which could be evacuated. As was to be expected, there was no marked difference in the intensity of the sound produced when operated in air and in a vacuum.

In the gold-leaf radiophone as used, the limit of audibility was attained for a light (radiant power) intensity of 4.8×10^{-5}

[7] It would be interesting to determine whether the effect is dependent upon the axial direction of exposure. In the present case the needle-crystals were parallel to the electrodes.

watts. Using a larger receiver and amplifier and a larger current (which was 0.2 amp. in the present tests) through the receiver, the sensitivity could be greatly increased.

SUMMARY

This paper summarizes the results of an investigation of various substances (1) for an increase in electrical conductivity caused by the action of light upon them, and (2) for electrical discharging activity when they were charged to a negative potential in an evacuated chamber and exposed to light.

Pure gallium and silver sulphide were found to have but small photoelectric discharging action when charged to a negative potential and exposed to light.

No change on exposure to light was observed in the electrical conductivity of tellurium, boleite, bismuthinite, and mixtures of the sulphides of lead and antimony.

An increase in electrical conductivity on exposure to light was observed in crystals of selenium, stibnite, boulangerite, jamesonite, and silver sulphide.

Experiments are described in which crystals of bismuthinite were joined through a battery to the grid circuit of an audion amplifier and a telephone. A change in current in this circuit affected the telephone. The light stimulus was interrupted by means of a rotating sectored disk, as used in Bell's selenium photophone. When using a cell or crystal of selenium the fluctuations in light intensity produced a sufficient change in conductivity to cause a musical note in the telephone. Similarly, in several samples of a crystal of bismuthinite a change in conductivity was produced, which caused an audible sound in the telephone. However, from various tests it is believed that this is not a true photoelectrical change (increase) in conductivity, but is due to a thermal resistance change within the crystal or to a change of resistance at the point of contact of the crystal with the metal electrodes between which the crystal was held by compression.

Experiments are described in which a thin blackened strip of platinum or of gold-leaf is joined through a battery to an audion amplifier. The variation in temperature and hence in the resistance of and in the current through the strip, caused by the fluctuation in intensity of the intermittent light, was sufficient in magnitude to produce an audible sound in the telephone receiver.

GENETICS.—*The average correlation within subgroups of a population.* SEWELL WRIGHT, Bureau of Animal Industry.

In studying the relationship of characters it often happens that the available data consist of a number of more or less differentiated groups, each one of which is by itself rather small for the calculation of a coefficient of correlation. Sufficiently large numbers can be obtained by combining all into one table, but if this is done the correlation due to differentiation of the subgroups among themselves complicates the interpretation. The coefficients for the whole population and for the means of the subgroups are easily calculated, but the calculation of coefficients within the subgroups may be a very tedious task if these are numerous.

It seems desirable therefore to have a method by which the average correlation for the subgroups can be derived directly from the distribution surfaces of the whole population and that of the means of the subgroups. The very simple formula discussed below has been useful to the writer and does not seem to be well known.

Assume that a population is composed of a number of subgroups which may be expected, within the limits of random sampling, to show the same correlation between two variables x and y and the same standard deviations. They may, however, be of varying sizes and be differentiated from each other significantly with respect to the mean values of x and y.

Let $\sigma_{x(g)}$, $\sigma_{y(g)}$, $r_{xy(g)}$ be the average standard deviations and the average correlation between x and y for the individuals within a single subgroup. Let $\sigma_{x(m)}$, $\sigma_{y(m)}$, $r_{xy(m)}$ be the corresponding values for the means of the subgroups weighting each mean

with the number of individuals involved. Let $\sigma_{x(t)}$, $\sigma_{y(t)}$, $r_{xy(t)}$ be the values for the total population. The average standard deviations within the subgroups can be calculated at once, as the variability of the whole population is compounded of the variability of the means of the subgroups and the independent variability of the individuals about these means.

Thus,
$$\sigma^2_{x(t)} = \sigma^2_{x(m)} + \sigma^2_{x(g)}$$
$$\sigma^2_{y(t)} = \sigma^2_{y(m)} + \sigma^2_{y(g)}$$

It is evident that the mean values of x and y for the total population are identical with those for the weighted means of the subgroups. Take the intersection of these means as origin and consider the contribution of a given subgroup to the term $\Sigma X_{(t)} Y_{(t)}$ in the formula for the coefficient of correlation for the total population.

$$r_{xy\,(t)} = \frac{\Sigma X_{(t)} Y_{(t)}}{n_{(t)} \sigma_{x\,(t)} \sigma_{y\,(t)}}$$

Let $X_{(m)}$, $Y_{(m)}$ be the deviations of the means of the subgroup from the origin. Let $X_{(g)}$, $Y_{(g)}$ be the deviations of any point within the subgroup from the center of the latter. $X_{(m)} + X_{(g)}$, $Y_{(m)} + Y_{(g)}$ are the coordinates of the point. For any such point there is a point of equal frequency at an equal distance on the opposite side of the center of the subgroup in the ideal case in which the subgroup is perfectly symmetrical about two perpendicular axes. Normal chance distributions tend to approach this ideal case. The coordinates of this point are $X_{(m)} - X_{(g)}$, $Y_{(m)} - Y_{(g)}$.

The sum of the products of the coordinates of such symmetrically placed points is as below.

$$\begin{array}{l}
X_{(m)} Y_{(m)} + X_{(m)} Y_{(g)} + X_{(g)} Y_{(m)} + X_{(g)} Y_{(g)} \\
X_{(m)} Y_{(m)} - X_{(m)} Y_{(g)} - X_{(g)} Y_{(m)} + X_{(g)} Y_{(g)} \\
\hline
2X_{(m)} Y_{(m)} \qquad\qquad\qquad\qquad\qquad\qquad + 2X_{(g)} Y_{(g)}
\end{array}$$

The sum of the products for all points in the subgroup, taken thus in pairs, is $n_{(g)} X_{(m)} Y_{(m)} + \Sigma X_{(g)} Y_{(g)}$ where $n_{(g)}$ is the number in the subgroup.

The correlation within a subgroup is

$$r_{xy\,(g)} = \frac{\Sigma X_{(g)} Y_{(g)}}{n_{(g)}\, \sigma_{x\,(g)}\, \sigma_{y\,(g)}}$$

$$\Sigma X_{(g)} Y_{(g)} = r_{xy\,(g)}\, \sigma_{x\,(g)}\, \sigma_{y\,(g)}\, n_{(g)}$$

The correlation and standard deviations within a subgroup are assumed constant. Hence $n_{(g)}$ is the only variable in the expression above.

Combining all subgroups:

$$r_{xy\,(t)} = \frac{\Sigma n_{(g)} X_{(m)} Y_{(m)} + r_{xy\,(g)}\, \sigma_{x\,(g)}\, \sigma_{y\,(g)}\, \Sigma n_{(g)}}{\sigma_{x\,(t)}\, \sigma_{y\,(t)}\, \Sigma n_{(g)}}$$

$$= \frac{r_{xy\,(m)}\, \sigma_{x\,(m)}\, \sigma_{y\,(m)} + r_{xy\,(g)}\, \sigma_{x\,(g)}\, \sigma_{y\,(g)}}{\sigma_{x\,(t)}\, \sigma_{y\,(t)}}$$

Thus the relation between the correlations and standard deviations of the total population, of the weighted means of subgroups, and of the individuals within an average subgroup are expressed by the following formula:

$$r_{xy(t)}\ \sigma_{x(t)}\ \sigma_{y(t)} = r_{xy(m)}\ \sigma_{x(m)}\ \sigma_{y(m)} + r_{xy(g)}\ \sigma_{x(g)}\ \sigma_{y(g)}$$

The following example deals with correlation between weight at birth and weight at the age of a year in male guinea-pigs born in litters of three in an inbreeding experiment carried on by the Animal Husbandry Division. In this experiment, 24 families have been developed by exclusively brother-sister matings from 24 original pairs. These 24 families have become strongly differentiated in various respects which can not be ascribed merely to variation in vigor. The present data involve records collected up to a certain date and include animals from the first to the 15th generation of inbreeding. There were 560 guinea-pigs in all families combined. This mixed population gives a correlation of $+ 0.375 \pm 0.024$. The correlations of the means of the 24 families, each weighted by the number of individuals, gives $+ 0.630 \pm 0.083$. In order to discover the average correlation within the families apart from the differentiation between families, correlations were calculated separately for the 8

largest families, containing 297 guinea-pigs. These contained, between 32 and 45 guinea-pigs each. Naturally, the coefficients varied greatly but all but one were positive and the weighted average came out + 0.256 ± 0.036, showing a substantial correlation. This, however, does not use all the data. A calculation directly from the correlation and standard deviations of the total population and the array of means, by the method suggested in this paper, gives + 0.308 ± 0.026 as the average within a family. This agrees reasonably well with the first calculation, uses all the data and involves very much less labor. Table 1 shows the constants used in calculating the average correlation within families and the averages derived from the 8 largest families as a check. σ_b and σ_y are the standard deviations, in grams, of birth weight and year weight respectively.

TABLE 1

CONSTANTS USED IN CALCULATIONS

	σ_b^2	σ_y^2	σ_b	σ_y	$\sigma_b\sigma_y$	$r_{by}\sigma_b\sigma_y$	r_{by}
Total (560 pigs)....	130.53	14,852	11.425	121.87	1,392.4	522.15	+0.375±0.024
24 family means....	20.50	4,837	4.528	69.55	314.9	198.39	+0.630±0.083
Average family (deduced)...........	110.03	10,015	10.49	100.08	1,049.8	323.76	+0.308±0.026
Average 8 families with 297 pigs.....	108.78	8,915	10.43	94.42			+0.256±0.036

GENETICS.—*A new case of metaphanic variation in grasses and its significance.* J. DUFRENOY, Station Biologique d'Arcachon. (Communicated by K. F. Kellerman.)

In his recent work on the *Hybrids of Zea ramosa and Zea tunicata,* G. N. Collins described these two mutants of maize as being ancestral forms. In crossing them "the hope was entertained that their combination might bring to light still other ancestral characters." This hope was not fulfilled, but important data were obtained and the conclusions brought forth seem to have a wide bearing.

We found them to apply fairly well to the case of *Dactylis glomerata.*

Two forms of *Dactylis glomerata* have been described, the true *D. glomerata* with a dense inflorescence, the branches at its base being less than 5 mm. long, and *D. glomerata ramosa* with a divided inflorescence, the basal parts being supported by branches 10 to 60 mm. long. The specialized character of *D. glomerata* is the suppression of the basal branches in the inflorescence, the whole inflorescence being the homologue of the terminal inflorescence of *D. glomerata ramosa.* This latter, which is less differentiated, may be considered an ancestral form.

In a meadow at Barèges (Hautes-Pyrénées, France) careful examination of hundreds of *D. glomerata* and *D. glomerata ramosa* led to the discovery: (1) of two inflorescences, bearing sterile spikelets, to be compared with the sterile ear of *Zea tunicata;*[1] (2) of a case of metaphanic variation which is most remarkable as it actually brings to light ancestral characters.

Green foliage organs, 23 to 25 mm. long, developed between the glumes, some of which yielded ♂ and ♀ reproductive organs. Some of the foliage organs enclosed normal, rudimentary, or abnormal stamens and pistils, or rudimentary leaves developed where pistils should have been. These metaphanic variations may be compared with those observed by Collins in the terminal inflorescence of full tunicate plants of maize. Successive transverse sections displayed all gradations in the forms of ♂ reproductive organs from the microsporangia of thallophytes to the stamens of flowering grasses.

Twelve microsporangia were imbedded in the parenchymatous tissue at the base of the foliage organ, which was thus a true homologue of the thallus of nonflowering plants. Some of these microsporangia were rudimentary and contained cells scarcely different from the parenchymatous neighboring cells, while others contained pollen-grains surrounded by nutritive cells. In the upper sections these microsporangia became more and more individualized and were freely grouped two by two as stamens.

[1] Collins, G. N. Journ. Agr. Research, 9: pl. 15.

The nondifferentiated foliage organ which bears ♂ and ♀ reproductive organs, and continues to act as an assimilating organ, being thus at the same time green and fertile, may be considered to represent one of the possible forms of the ancestral organs of grasses.

From the data presented the following conclusions may be drawn, which confirm the theories of Bower, MacDougal, and Dufrenoy:

Organs of grasses were at first all fertile but most of them became sterile under the pressure of ecologic factors. The vegetative activity overshadowed the reproductive activity and most organs become assimilating organs, viz., leaves. A few remained fertile, and responded in diverse ways to their reproductive specialization, attaining their greatest differentiation in ordinary maize.

BIBLIOGRAPHY

Collins, G. N. *Hybrids of* Zea ramosa *and* Zea tunicata. Journ. Agr. Research, **9**: 383–395, pl. 13–21.

MacDougal, D. T. *Aridity and evolution.* Plant World, **12**: 221.

Dufrenoy, J. *Les données actuelles et les problèmes de la phytogéographie.* (Literature cited.) Rev. Gén. Sci., **27**: No. 10.

ORNITHOLOGY.—*Diagnosis of a new pycnonotine family of Passeriformes.* Harry C. Oberholser, Biological Survey.

It requires but a superficial examination to discover that the genus *Irena* is out of place among the Pycnonotidae. Apparently it has been referred to that family because of its conspicuous nuchal hairs, which are so characteristic a feature of the bulbuls; and because of the lack of a better place.

That this disposition has not been considered satisfactory is evidenced by Dr. R. B. Sharpe's reference of *Irena* to the Dicruridae,[1] which action was, however, soon, and properly, repudiated by Dr. Sharpe himself.[2] As a matter of fact, the fairy bluebirds, as the members of the genus *Irena* are called, with their metallic

[1] Cat. Birds Brit. Mus., **3**: 265. 1877.
[2] Cat. Birds Brit. Mus., **6**: 174. 1881.

plumage and heavily plumed nostrils, do, at first glance, very much resemble the drongos (family Dicruridae); but the possession of twelve instead of ten rectrices definitely excludes them from that group. Since, as above indicated, the birds now comprised in the genus *Irena* Horsfield are not properly referable to the Pycnonotidae or to any other recognized family, it becomes necessary to create for them a new group, to be called

Irenidae, fam. nov.

Diagnosis.—Readily differentiated from the Pycnonotidae by the strongly corvine bill and the densely and entirely feathered nostrils and nasal fossae.

Family characters.—Bill thick and heavy, but somewhat compressed, the culmen rather sharply ridged, the gonys rounded; terminal portion of maxillar tomia notched; mental apex opposite anterior end of nasal fossae; nostrils small and subrounded, situated in the anterior end of nasal fossae, and entirely and thickly covered with closely appressed antrorse feathers and bristles; head completely feathered; nuchal hairs present and of moderate length; tail of twelve stiffish feathers, slightly rounded, and making up nearly half the total length of bird; wings rather long and rounded; tertials short; first (outermost) primary spurious, but more than one-half the length of second; feet rather small, the claws moderately developed; tarsi short, scutellate, but sometimes rather indistinctly so.

Type genus.—*Irena* Horsfield.

Remarks.—The birds of this new family comprise eight current species, two of which are, however, but subspecies, and an additional new subspecies, hereinafter described. Authors have hitherto included all these in the single genus *Irena*, but structural differences necessitate the division of this into two genera, as follows:

Irena Horsfield

Irena Horsfield, Trans. Linn. Soc. Lond., ser. 1, XIII, pt. 1, May, 1821, p. 153 (type by monotypy, *Coracias puella* Latham).

Generic characters.—Tail rather long, about four-fifths of wing; lower tail-coverts falling short of end of tail by more than one and one-half times the length of tarsus; and upper tail-coverts falling short of end of tail by two or more times the length of tarsus.

Type.—*Coracias puella* Latham.

In the original diagnosis of *Irena* the only species that Horsfield cites is "Coracias puella, *Lath. Ind. Orn.* 171," with which he misidentifies Javan specimens of the species not until long afterward described as *Irena turcosa* by Walden. The type of this genus must, therefore, be the only species mentioned, *Coracias puella* Latham; not, as Sharpe[3] states, *Irena turcosa* Walden; particularly since the latter had no standing whatever at the time of the institution of the generic name *Irena.*

Of the forms now allotted to the restricted genus *Irena*, one, *Irena ellae* Steere, is certainly but a subspecies of *Irena melanochlamys* Sharpe, as individual variations in these two overlap the differences. With this change, the species of this group will be as follows:

Irena melanochlamys melanochlamys Sharpe.
Irena melanochlamys ellae Steere.
Irena cyanogastris Vigors.
Irena puella (Latham).
Irena tweeddalii Sharpe.

Glauconympha, gen. nov.

Generic characters.—Similar to *Irena* Horsfield, but tail shorter, only three-fourths of the length of wing; lower tail-coverts much longer, falling short of end of tail by less than length of tarsus, and sometimes reaching even beyond the end of tail; and upper tail-coverts much longer, falling short of end of tail by not more than the length of tarsus.

Type.—*Irena cyanea* Begbie.

The bird from Borneo and Sumatra, *Irena crinigera* Sharpe, is by individual variation subspecifically connected with *Irena*

[3] Cat. Birds Brit. Mus., 6: 174. 1881.

cyanea from the Malay Peninsula, and must therefore stand as *Glauconympha cyanea crinigera.* Its name *criniger* is a Latin adjective (not a noun, as some authors apparently think) of which the feminine nominative is *crinigera*, as above written. Birds of this species from the Barussan Islands, off the western coast of Sumatra, are found to differ subspecifically from the typical race of the mainland, and as they are apparently undescribed, may be called:

Glauconympha cyanea megacyanea, subsp. nov.

Subspecific characters.—Similar to *Glauconympha cyanea crinigera* from Borneo and Sumatra, but larger; female with both upper and lower parts darker, more bluish (less greenish).

Description.—Type, adult female, No. 179254, U. S. Nat. Mus., Pulo Tuanku, Banjak Islands, January 23, 1902; Dr. W. L. Abbott. Upper surface dusky green blue No. 1,[4] but the tips of most of the feathers chessylite blue, and the interscapulum with a more greenish shade, the upper tail-coverts dark chessylite blue; tail brownish black, the middle pair of rectrices and outer webs of the three adjoining pairs, dark green blue slate; wings blackish fuscous, the lesser coverts dusky green blue No. 1, the broad edgings of median and greater coverts and tertials, and narrow margins of primary coverts, secondaries, and a few of the inner primaries, dark greenish blue like the interscapulum; lores and nasal feathers between neutral gray and deep neutral gray; sides of head and neck like the interscapulum; throat greenish blue, between dark gobelin blue and terre verte green; breast dull jouvence blue; abdomen dull, somewhat greenish capri blue; crissum dark orient blue; lining of wing fuscous, the outer feathers edged with greenish blue; "iris red; bill and feet black."

Measurements.—Male:[5] wing, 115–124 (average, 119.9) mm.; tail, 82.5–91 (86.6); exposed culmen, 21–23.5 (22.3); height of

[4] The colors here mentioned are based on Mr. Ridgway's "Color Standards and Color Nomenclature."

[5] Eleven specimens, from South Pagi Island, Nias Island, Pulo Mansalar. the Batu and Banjak Islands, western Sumatra.

bill at base, 9–10 (9.6); tarsus, 16–18.5 (17.5); middle toe without claw, 14–14.5 (13.7).

Female:[6] wing, 118–119 (average, 118.6) mm.; tail, 85–91 (88.1); exposed culmen, 23.5–24.5 (23.8); height of bill at base, 9.5–10.5 (10); tarsus, 17.5–19 (18.1); middle toe without claw, 14–15 (14.5).

Geographic distribution.—Nias, Mansalar, the Pagi, Batu, and Banjak Islands, with doubtless others of the Barussan chain off the western coast of Sumatra.

The subjoined measurements of *Glauconympha cyanea crinigera*, from Bornean and Sumatran specimens, are added here for convenience of comparison with those of the present new race:

Male.—Wing, 113.5–119 (average, 116) mm.; tail, 74–84.5 (81.5); exposed culmen, 21–23 (21.8); height of bill at base, 9–10.5 (9.5); tarsus, 15–18 (16.3); middle toe without claw, 13–14 (13.5).

Female.—Wing, 114–118 (average, 115.6) mm.; tail, 82–88 (84); exposed culmen, 22–24 (23.2); height of bill at base, 9–10.5 (9.6); tarsus, 16.5–19 (17.3); middle toe without claw, 14–14.5 (14.3).

The species and subspecies referable to the new genus *Glauconympha* are as follows:

Glauconympha turcosa (Walden).
Glauconympha cyanea cyanea (Begbie).
Glauconympha cyanea crinigera (Sharpe).
Glauconympha cyanea megacyanea Oberholser.

[6] Three specimens, from South Pagi Island, Nias Island, and the Banjak Islands, western Sumatra.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorised to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

RADIATION.—*The calculation of the constants of Planck's radiation equation; an extension of the theory of least squares.* HARRY M. ROESER. Bureau of Standards Scientific Paper No. 204 (Bull. Bur. Stds., **14**: 31–77). 1917.

The problem of computing from experimental data the constants, c_1 and c_2, of Planck's radiation equation for the distribution of energy in the spectrum of a black body is attacked by the method of least squares. The data were furnished by Dr. W. W. Coblentz. The observation equations were reduced by taking logarithms of both sides and assigning proper weights to the equations so transformed. The method of assigning weights is given in a general form that can be adapted to any scheme of transformation.

H. M. R.

PHYSIOLOGICAL OPTICS.—*The luminous radiation from a black body, and the mechanical equivalent of light.* W. W. COBLENTZ and W. B. EMERSON. Bureau of Standards Scientific Paper No. 305 (Bull. Bur. Stds., **14**: 255–268). 1917.

In this paper the visibility of radiation by the average eye is applied to radiation problems, including the luminous energy emitted by a black body at various temperatures, the luminous efficiency, the Crova wavelength, and the mechanical equivalent of light. The visibility curve of the average eye (125 observers) gives a mechanical equivalent of 1 lumen = 0.00161 watt of radiant energy of maximum visibility. Various other determinations give values varying from 0.00157 to 0.00160 watt. The most reliable data now available indicate a value of 1 lumen = 0.0016 watt of radiant energy of maximum visibility, or 1 watt = 625 lumens = 49.8 candles of radiant energy of maximum luminous efficiency.

W. W. C.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 791st meeting was held at the Cosmos Club, May 26, 1917. President BUCKINGHAM in the chair; 33 persons present. The minutes of the 790th meeting were read in abstract and approved.

Mr. C. F. MARVIN gave an illustrated paper on *Aerology in aid of aeronautics.* (No abstract.)

Discussion: The paper was discussed by Messrs. BUCKINGHAM, HERSEY, WHITE, and SWEET. Mr. LITTLEHALES mentioned the systematic rotation of wind velocity with change in altitude.

Informal communications: Mr. HUMPHREYS gave an explanation of the formation of the two kinds of sun dogs, or haloes, by reflection. Mr. BUCKINGHAM considered one application of the principle of dimensional homogeneity. In a communication about three years ago, the speaker had enunciated a certain theorem concerning the forms of physical equations, as a convenient formulation of the principle of dimensional homogeneity. The present communication referred to the further elucidation of the term "complete equation." By means of Lord Rayleigh's problem of the gravitational oscillations of a liquid spheroid, two methods were illustrated for treating universal constants which might be involved in the phenomenon described by the equation in question. It was further remarked that a similar choice of methods was available for dimensional constants which were not universal, and that one of the methods introduced a considerable simplification into the algebra of the process.

DONALD H. SWEET, *Secretary.*

ANNOUNCEMENT OF PROGRAM OF THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

During the season from October, 1917 to April, 1918, inclusive, the Anthropological Society of Washington, D. C., will provide a very interesting program of papers or lectures chiefly concerned with divers nations of Europe and the East now at war or likely to be involved before long, including especially some of our less known and smaller allies. The general plan of most of these monographs will be a résumé of earliest known data, racial origins, shiftings and blendings, historical development, and present status, aiming to further a more thorough acquaintance with these peoples, their characteristics and capabilities, and the causes which have made them what they are. The appended schedule may be subject to some changes in detail as the season advances and is now necessarily incomplete as to one or Two items, but will give a sufficient idea of what is to be expected. the society meets at 4.30 p.m. in rooms 42–43 of the new building of the National Museum on alternate Tuesdays, beginning October 2, 1917.

PROGRAM

Oct. 2, 1917: Dr. Ales Hrdlicka: *Bohemia and the Bohemians.*
Oct. 16, 1917: Dr. Mitchell Carroll: *The story of Greece.*
Nov. 6, 1917: Prof. James H. Gore: *Belgium.*
Nov. 20, 1917: Mr. George J. Zolnay: *Roumania, past and present.*
Dec. 4, 1917: Dr. Amandus Johnson: *Scandinavia.*
Mr. Juul Dieserud: *Certain customs of Norway.*
Dec. 18, 1917: ....*France.*
Jan. 15, 1918: Dr. Voyslav M. Yovanovitch: *Serbia.*
Jan. 29, 1918: ....*Italy.*
Feb. 12, 1918: Dr. Joseph Dunn: *Scotland.*
Feb. 26, 1918: Dr. B. Israeli: *Russia.*
March 12, 1918: Mr. E. T. Williams: *The origin of China.*
March 26, 1918: ....*Holland.*
April 9, 1918: Dr. Paul Haupt: *Mesopotamia and Palestine.*
April 22, 1918: Annual meeting and election of officers.

Some, perhaps most, of these lectures will be illustrated by lantern slides or otherwise. The public will be welcome.

Wm. H. Babcock,
President.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, October 20: The Biological Society, at the Cosmos Club, at 8 p.m.

Wednesday, October 24: The Medical Society, at the Medical Department of George Washington University, 1325 H Street, NW., at 8 p.m.

Saturday, October 27: The Philosophical Society, at the Cosmos Club, at 8:15 p.m. Program:

J. T. Tate and P. D. Foote: *Critical potentials for electrons in metallic vapors.* (Illustrated.) 30 minutes.

S. J. Crooker (by invitation): *Experiments on direct current corona.* (Illustrated.) 30 minutes.

Wednesday, October 31: The Medical Society, at the Medical Department of George Washington University, 1325 H Street, NW., at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and twenty-seventh day of each month.

CONTENTS

Original Papers

Page

Physics.—The resonance and ionization potentials for electrons in sodium vapor. John T. Tate and Paul D. Foote 517

Physics.—The photoelectric sensitivity of various substances. W. W. Coblentz and W. B. Emerson 525

Genetics.—The average correlation within subgroups of a population. Sewell Wright 532

Genetics.—A new case of metaphanic variation in grasses and its significance. J. Dufrenoy 535

Ornithology.—Diagnosis of a new pycnonotine family of Passeriformes. Harry C. Oberholser 537

Abstracts

Radiation 542

Physiological Optics 542

Proceedings

The Philosophical Society 543

Announcement of program of the Anthropological Society 544

Vol. VII

November 19, 1917

No. 19

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. VII NOVEMBER 19, 1917 No. 19

PHYSICS.—*Criteria for gray radiation.* Paul D. Foote, Bureau of Standards.

If certain materials, such as glowing carbon, are maintained at a constant temperature and the brightness of these materials compared spectrophotometrically with that of a black body at various temperatures, it is well known that the logarithm of the ratio of intensities for any wave length is a linear function of the reciprocal of the absolute temperature of the black body and that frequently the straight lines corresponding to various wave lengths intersect in a single point. The writer and Mr. Fairchild[1] have pointed out that this condition of the intersection of the so-called logarithmic isochromatics is no criterion for grayness of the non-black body. Dr. Hyde[2] has also established this point.

Dr. Nutting[3] in a recent paper concludes that the log isochromatics for a black body can not intersect in the manner described, except over a limited range of wave lengths and that the condition of approximate intersection and the condition for grayness may both be satisfied, but either may hold without the other

We disagree with both of these conclusions as applied to our work and desire to point out that the trouble is due partly to a

[1] Foote and Fairchild. J. Wash. Acad., 6: 194. 1916.
[2] Hyde. Ann. d. Phys., (4) 49: 144. 1916.
[3] Nutting. J. Wash. Acad., 6: 476. 1916.

confusion of terminology. Lummer and Pringsheim,[4] Benedict,[5] and Foote and Fairchild[6] have been considering always the ratio of intensities at two temperatures, while Dr. Nutting uses the intensity at a single temperature. It is unfortunate that the term "log isochromatics" has been applied to both types of curves for fifteen years. If one carries through Dr. Nutting's derivation upon the same basis as that used by the other writers,

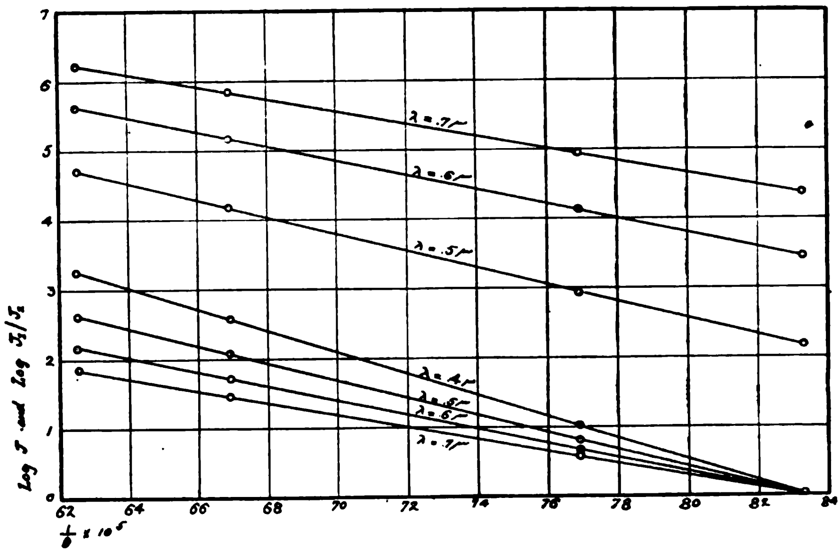

Fig. 1. Plot of log isochromatics for a black body

it is clear that the log isochromatics for black bodies and for a black body compared with a gray body always satisfy the "stigmatic condition" over the entire range of wave lengths from $\lambda = 0$ to $\lambda = \infty$. Furthermore, the condition of grayness of one or both of the radiators necessitates the intersection of the log isochromatics. On the contrary the intersection of the log isochromatics does not prove that the material compared is gray. All of these points were brought out in the earlier paper referred to.[7]

[4] Lummer and Pringsheim. Verh. d. D. Phys. Ges., 3: 36. 1901.

[5] Benedict. Ann. d. Phys., 47: 641. 1915.

[6] Foote and Fairchild. Loc. cit.

[7] Foote and Fairchild. Loc. cit.

As a concrete example we have plotted in figure 1 data for a black body at absolute temperatures 1200°, 1300°, 1500°, and 1600°. The upper four straight lines represent Dr. Nutting's method of plotting. The lower four straight lines represent the method originally suggested by Lummer. The lower four lines converge at $\vartheta = 1200°$ absolute, while, as Dr. Nutting concludes, the upper four do not converge. It may be pointed out that no one ever contended they did converge to a common point. Indeed the points of intersection are given in table 1.

TABLE 1

TEMPERATURES AT WHICH INTERSECTIONS OCCUR ON THE BASIS OF DR. NUTTING'S METHOD OF PLOTTING

λ	0.5 μ	0.6 μ	0.7 μ
μ	*degrees*	*degrees*	*degrees*
0.4	9525	5874	5491
0.5		5238	4869
0.6			4428

When the data for equilibrium radiation are properly plotted there is no "approximation" to the "stigmatic condition." It is a definite intersection as clearly shown in the earlier paper referred to.

In conclusion it is desirable to point out the following facts: (1) A gray body is by definition one for which at a true temperature ϑ the ratio of the intensity of its emission to that of a black body at temperature ϑ, at any given monochromatic wave length, is independent of the wave length chosen. (2) There are two types of log isochromatic curves, one referring to ratio of intensities, the other to the actual values of intensity. The former type of curve is the one of interest in the present discussion. (3) The intersection of log isochromatics for the radiation from a non-black body spectrophotometrically compared with that from a black body is not a criterion for grayness of the non-black body. (4) The temperature at which intersection occurs is not the true temperature of the non-black body,

unless the radiation is gray, but is the so-called "color temperature." (5) In the case of intercomparison of black or gray bodies perfect intersections of the log isochromatics occur for all wave lengths, and the temperature at which the intersection occurs is the true temperature of one of the radiators in question. (6) It is theoretically possible to have two radiators at different temperatures, one gray and the other far from gray, with each showing identically the same spectral distribution of energy.

GEOLOGY. *Clay derived from volcanic dust in the Pierre in South Dakota.* EDGAR T. WHERRY, Bureau of Chemistry.[1]

At several places near the southwestern corner of the state of South Dakota there is found, interbedded in the Pierre formation, a peculiar clay. During the early part of May, 1917, the writer made a field examination of the occurrence of this material, and as a result of his observations, combined with microscopic and chemical examination of the samples collected, has come to the conclusion that this clay represents an altered volcanic dust, accumulated in the sea during Pierre time.

Occurrence. The clay occurs at a number of places along a line, convex toward the south and over 50 miles long, extending from Buffalo Gap to Provo, around the southern end of the Black Hills. It forms numerous beds varying from a fraction of an inch to 4 feet in thickness, interbedded with and sharply delimited from the black shale characteristic of the Pierre; the latter here contains fish bones and the shells of various lamellibranchs and cephalopods, such as Inoceramus and Baculites, clearly fixing its horizon.[2] The majority of the clay beds can be traced practically continuously and without marked variation in thickness throughout the whole of this distance; a very few of them are lenslike and more limited in extent. Near Pedro,

[1] This paper was prepared while the writer was connected with the National Museum.

[2] Specimens of these have been kindly examined and identified as Pierre types by Messrs. J. W. Gidley, of the National Museum, and T. W. Stanton, of the Geological Survey.

50 miles further northwest, a thick bed of similar clay (there called bentonite) occurs at approximately the same geological horizon, but the details of the section are so different that the equivalence of the two deposits can not be regarded as established. These stratigraphic relations are shown in the columnar sections in figure 1.

The continuity of practically every bed of clay and the comparatively slight variation in thickness shown by them throughout the entire distance represented, over 50 miles, are well brought out by these sections. The most remarkable instance of this continuity is in one of the ½-inch clay beds that lies about 5 feet above the main (3 to 4-foot) bed; it can be recognized in every exposure.

Character. The clay forms dense, compact masses, breaking with a conchoidal fracture. When fresh it is deep gray, but on weathering it becomes yellowish, owing to oxidation of the iron compounds present. The weathered outcrops are strewn with innumerable gypsum crystals, resulting from the action of sulfuric acid (arising from oxidation of pyrite, which is abundant in the shale and in places occurs in the clay itself) on calcite, which is distributed through both rocks.

On treatment with water the clay swells up conspicuously, absorbing somewhat more than its own weight of water and becoming sticky or plastic; on adding an excess of water it slumps down to a flocculent slime. This swelling is evidently due to the absorption of water by porous, spongelike, clay particles.

Under the microscope the clay shows an extremely fine grain. When immersed in oil the individual particles, in so far as they can be made out, exhibit slight, variable, but almost universal double refraction, brought out more especially by the insertion of a sensitive-tint selenite plate. Immersion in water, on the other hand, causes a marked diminution in the double refraction, many grains becoming quite isotropic. The index of refraction of the clay, determined by the immersion method, is about 1.50; but it varies, of course, with the water content, and, because of the porous character of the particles, tends to increase slightly

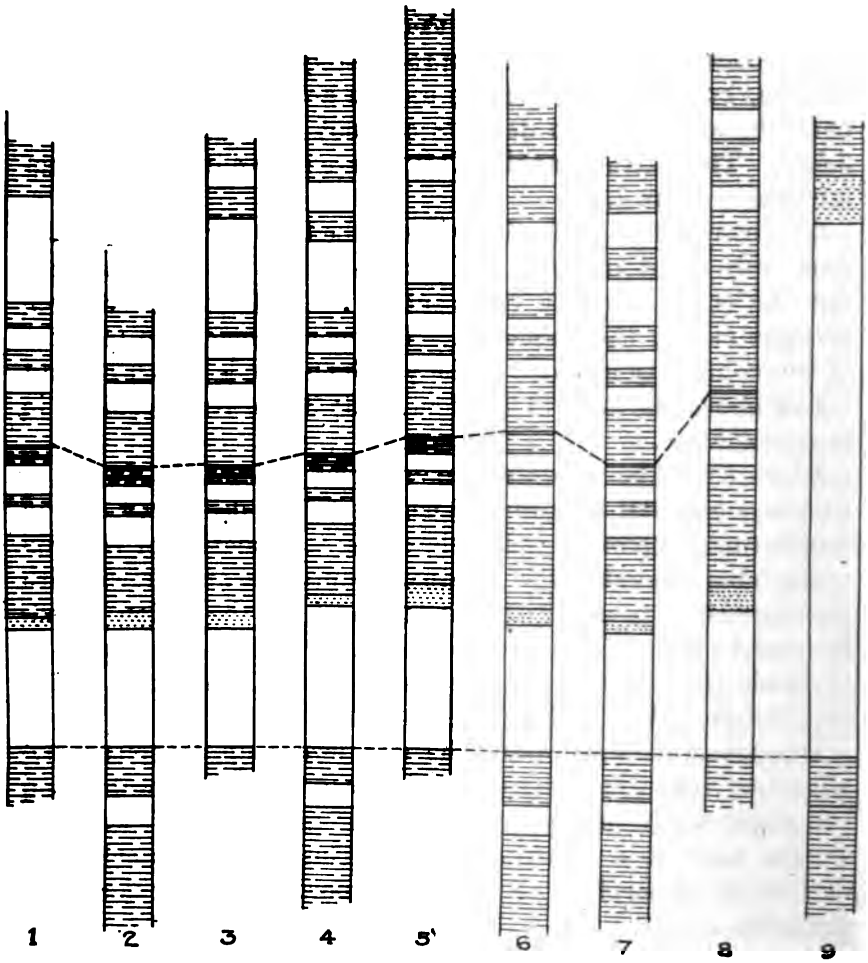

Fig. 1. White areas represent clay, horizontal-lined ones shale, and dotted ones alternations of clay and shale, Scale, ¼ inch = 1 foot. The bottom of the main clay bed is assumed to be at the same horizon in all sections; the 1-inch clay bed lying about 5 feet above the top of the main bed is connected by broken lines.

1. Pit on "Hat No. 1 Lode," 3 miles south of Buffalo Gap, South Dakota.
2. Hill slopes on "Hat No. 2 Lode," ¼ mile south of No. 1.
3. Hill slopes on "Hat No. 5 Lode," 1 mile south of No. 2.
4. Cliff at assessment tunnel, ¾ mile south of No. 3.
5. Hill slopes ½ mile southwest of No. 4.
6. Hill slopes along Hat Creek, 1 mile west of Ardmore, South Dakota, about 40 miles southwest of No. 5.

7. Hill slopes one mile northeast of Ardmore, 2 miles from No. 6.

8. Hill slopes 1½ miles southeast of Provo, South Dakota, about 10 miles northwest of No. 6.

9. Ledges ½ mile southeast of Pedro, Wyoming, about 50 miles northwest of No. 8.

on their standing several hours in contact with the immersion oils.

By virtue of its porosity the clay is able also to adsorb dyes, especially methylene blue. A moderately strong aqueous solution of this substance is completely decolorized on filtering it through a thin layer of the clay, which becomes deep blue. This behavior, in connection with the absorption of water and accompanying swelling, points clearly to its amorphous, colloidal nature. The faint, variable, double refraction which it exhibits when examined in oils does not oppose this view, not being necessarily indicative of crystallinity.[3] There is every reason to believe, on the contrary, that it is connected with strain in the amorphous, colloidal mass, incident to partial loss of water. The practical disappearance of the double refraction when water is added is the result of the relief of this strain, the normal, amorphous condition being thereupon restored.

Average samples contain, in addition to the clay particles, a very few grains of feldspar, biotite, and magnetite. Samples collected from different parts of the main bed (or, for that matter, from any of the beds) show, however, a marked downward increase in the amount of such minerals. When a lump of the clay from the lowermost 2 inches of this bed is stirred up in water several times and the cloudy liquid poured off from the solid matter, a very noticeable residue remains. This is found on microscopic examination to contain the following minerals, all in practically fresh, unaltered condition: plagioclase feldspar—mostly andesine, mica—mostly biotite, magnetite, and calcite (the last representing a precipitate from the sea water).

[3] That optical anomalies, and especially double refraction in normally isotropic minerals, can be produced by strain is well known; and since the preparation of this paper, this point has been emphasised by A. F. Rogers (Journ. Geol., 35: 519. 1917).

No quartz has thus far been detected in any sample from the region. Some clumps of clay are not flocculated, but remain behind with the sandy residue. These probably represent incompletely disintegrated grains of the original material from the

TABLE 1

ANALYSIS OF CLAY

	1	2	3	
SiO_2	51.1	64.0	62.3	63.9
TiO_2			1.6	
Al_2O_3	15.4	19.4	16.1	
Fe_2O_3	4.5	5.6	3.6	6.0
FeO			2.2	
MnO			0.2	
MgO	3.8	4.8	2.0	
CaO	5.2	4.3	4.1	
Na_2O	1.5	1.9	3.6	6.0
K_2O			2.4	
H_2O-	13.1			
H_2O+	4.0		1.5	
CO_2	[1.4]			
P_2O_5			0.4	
Total	100.0	100.0	100.0	

1. Analysis of fresh clay from bottom of main bed, 8 miles south of Buffalo Gap, South Dakota; partial analyses of other samples show variations of 1 or 2 per cent in the several constituents, but not enough to affect materially the conclusions here drawn.

2. Same, recalculated to 100 per cent after deducting H_2O and CO_2 and the amount of CaO corresponding to the latter.

3. Composition of average mica-andesite, after Osann, in Daly, *Igneous rocks and their origin*, New York, p. 26, 1914.

decomposition of which the clay has been derived. While no complete, conclusive proof as to the nature of this substance is obtainable, the irregular shapes and absence of crystal outline of these masses, together with their isotropic, amorphous character, lead to the inference that they originally consisted of volcanic glass. This, with the minerals above noted, would constitute a mica-andesite rock.

The chemical composition of the clay is given in table 1.

Origin. Any theory as to the origin of this clay deposit must account for the peculiar features above noted,—the remarkable continuity of beds for many miles along the strike, the absence of quartz, the presence of fresh feldspar and mica, and the porous, colloidal character of the clay itself. It is believed that these facts are adequately explained by the volcanic dust theory, as here outlined.

That there was considerable volcanic activity in the northern Rocky Mountain region during late Cretaceous and Tertiary times has long been recognized; and that volcanic dust ("ash") was often carried far east over the Great Plains is well known. The Tertiary dusts have been observed throughout Nebraska and as far east as Plattsmouth, Iowa;[4] and in an informal communication before the Geological Society of Washington, Dr. T. W. Stanton has described an occurrence of volcanic dust in the Cretaceous (Fox Hills) in southern North Dakota.[5] But eruptions yielding volcanic dust also occurred still earlier in the Cretaceous, notably in Benton time, as recently emphasized by Hewett.[6] On the occasion of the writer's visit to South Dakota Prof. Freeman Ward, of the University of South Dakota, pointed out a thin stratum of whitish material, which probably represents such an occurrence, in the Benton group as exposed in the Missouri River bluffs in the northeast corner of Nebraska, opposite Vermilion, South Dakota. There is thus no reason to question the possibility that dust-producing eruptions occurred during Pierre time and that this dust was transported as far as what is now southwestern South Dakota.

When volcanic dust falls on dry land it is likely to collect on the lee side of elevations, the deposits being relatively thick in proportion to their lateral extent and showing little or no stratification. Numerous minute laminations may result, on the other hand, from its deposition in shallow lakes.[7] But when blown out over a body of deep water, such as the interior sea that occupied what is now the central part of the North Ameri-

[4] BARBOUR, E. H. *Nebraska pumicite.* Nebraska Geol. Survey, 4: 361. 1916.
[5] Journ. Wash. Acad. Sci., 7: 80. 1917.
[6] Ibid., 7: 196. 1917.
[7] BARBOUR. Loc. cit.

can continent during much of Cretaceous time,. the dust would naturally become spread more or less evenly and widely over the bottom. In settling it would, furthermore, undergo at least partial sorting into heavier and lighter, or coarser and finer, particles, and develop some degree of stratification. Grains of feldspar, quartz, hornblende, mica, and other crystalline minerals would settle more rapidly than those of volcanic glass, full of gas-bubble cavities. The lower part of any stratum would thus naturally contain the bulk of the crystalline minerals present in the dust, the upper part most of the glass.

The crystalline minerals, not having been long exposed to atmospheric weathering before deposition, should appear in the sediment in essentially fresh condition. The volcanic glass, on the other hand, being porous and charged with gases,—including, no doubt, hydrochloric acid, sulfur dioxide, and other chemically active gases from the volcanic emanations,—would be likely to undergo "auto-metamorphism," in the sense in which this term has recently been used by H. C. Sargent.[8] The product would naturally be expected to have peculiar properties. When it is considered that rain water containing traces of carbon dioxide, acting on crystalline feldspars at the earth's surface, often produces amorphous halloysite ("kaolinite"), the probability of the development of an amorphous, colloidal clay-material from the originally amorphous volcanic glass in this case is evident. In the former instance most of the alkalies and alkaline earths and part of the silica are dissolved and carried away by the rain water; in the latter, water circulation and diffusion would necessarily be so hampered that little removal of constituents could be expected, except perhaps the most soluble ones, the alkalies. The clay should therefore differ from the original glass chiefly by the presence of more water, and less alkalies. How this is borne out by the composition actually observed is shown in the analyses given in table 1.

The clay here described is hardly to be regarded as a definite mineral. It more probably consists of mixed gels of alumina and silica, with adsorbed alkalies and water. Resemblances in

[8] Paper given before the Geological Society of London; abstract in Nature, 99: 59. 1917.

composition between it and halloysite[9] or leverrierite[10] might be traced, but these resemblances are purely accidental. In basic plagioclase feldspars, and, correspondingly, in andesite glass, the ratio $Al_2O_3 : SiO_2$ does not greatly exceed 1 : 2, and this ratio is preserved in the clay. The same ratio happens to hold in the two minerals mentioned, but there the resemblance ceases. Mere numerical similarity does not imply relationship in such cases, where one substance is a mixture of gels and the others definite (even though somewhat variable) minerals.

The theory above outlined accounts for the peculiar features of this occurrence in an entirely satisfactory manner. It appears, further, that no other mode of formation would explain many of these features. For instance, all clay brought down by rivers and deposited in the sea contains a large amount of fine quartz grains and rarely any feldspar; but the absence of quartz and the presence of feldspar are two of the most characteristic features of this deposit. The sediments brought into the sea by rivers, moreover, tend to be deposited in lenses or wedges, and their beds rarely extend continuously for more than a few hundreds or thousands of feet. As opposed to this relation, we find here beds, from 1 inch to 4 feet thick, extending for a distance of at least 50 miles, without marked variation in their thicknesses. Finally, the clayey matter in normal sediments has been for so considerable a period exposed to such varied chemical agents—rain water containing carbon dioxide, river water containing small amounts of salts, and sea water containing larger amounts of these,—that, although it may remain amorphous, it has attained a certain degree of stability and definiteness of composition and, since it is no longer particularly porous, after drying out it does not in general take up water again with marked swelling; while the clay here described is highly porous and exhibits the latter property prominently.

The theory of volcanic-dust origin therefore appears to be the only one that satisfactorily accounts for the features shown by this remarkable deposit.

[9] Halloysite being apparently a stable, definite mineral, corresponding to amorphous kaolinite, as shown by E. S. Larsen and the writer (Journ. Wash. Acad. Sci., 7: 178. 1917.) and by A. F. Rogers (Op. cit. 535).

[10] LARSEN, E. S., and WHERRY, E. T. Journ. Wash. Acad. Sci., 7: 216. 1917.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*Triangulation in Georgia.* C. H. SWICK. U. S. Coast and Geodetic Survey Special Publication No. 43. Pp. 53, with 9 illustrations. 1917.

This is one of a series of volumes published by the U. S. Coast and Geodetic Survey which give the data for triangulation stations established by that bureau. The present volume contains the geographic positions of approximately 590 triangulation stations in the state of Georgia, in the interior and on the coast. It is expected that the descriptions of these stations in Georgia will be published by the Coast and Geodetic Survey in the near future in a second volume.

In the published form the results of triangulation of the country are made accessible to geographers, surveyors, and engineers for control of maps, surveys, and engineering works of various kinds. The results of this triangulation are also of value to geodesists in the determination of the figure of the earth and in investigations in the subject of isostasy.

C. H. S.

ELECTRICITY.—*Some electrical properties of silver sulphide.* GEORGE W. VINAL. Bureau of Standard Scientific Paper No. 310 (Bull. Bur. Stds. **14**: 331–339). 1917.

Silver sulphide may be prepared in the form of short wires or thin strips like a metal. The wire, which must be drawn hot, was found to conduct electricity like a metal of high specific resistance and approximately zero temperature coefficient. A strip of sulphide rolled at room temperature has a large temperature coefficient and shows both metallic and electrolytic conduction. It has a volt-ampere

curve characteristic of a pyroelectric conductor. The strips are sensitive to small alternating currents, which increase the resistance enormously, while small direct currents have the opposite effect. The specific resistance has been measured and experiments made on the electrochemical decomposition. G. W. V.

OPTICS.—*An investigation of the axial aberrations of lenses.* E. D. TILLYER and H. I. SCHULTZ. Bureau of Standards Scientific Paper No. 311 (Bull. Bur. Stds. **14**: 341–369). 1917.

The errors which affect the definition of a lens are discussed, and methods of graphically representing the central errors described. The condition for freedom from coma near the axis is arrived at. The relative importance of the errors in different types of lenses is discussed. Hartman's method is extended, permitting one set of measurements to give all the important central errors—spherical aberration, zonal variation of equivalent focal length, and axial and oblique achromatism. The apparatus and procedure are described, and the accuracy of the adjustments and of the measurements discussed. The method is applicable to all systems of relatively short focus and large aperture, such as photographic lenses, projection lenses, and telescope objectives, and also to complete optical systems. The results of the method as applied to a complete telescope are discussed, and shown to be independent of the accommodation of the observer. Seventeen sets of curves are given for as many different lenses, and an illustrative discussion of one set of curves, together with a general description of the types of lenses represented by each group of curves is included. E. D. T.

SPECTROSCOPY.—*Wave-length measurements in spectra from 5900 Å to 9600 Å.* W. F. MEGGERS. Bureau of Standards Scientific Paper No. 309 (Bull. Bur. Stds. **14**: 317–329). 1917.

Plates stained in a mixture of dicyanin, water, alcohol, and ammonia were used to photograph the arc spectra of twenty of the chemical elements, including the alkali metals, the alkaline earths, and elements commonly found in iron as impurities; a concave grating of 640 cm. radius, mounted in parallel light was used. This spectrograph gives a dispersion of about 10Å per millimeter in the first order. Exposures of thirty minutes sufficed to record waves longer than 9000 Å. In this paper the wave-lengths in International Angstroms are given for the arc spectra of the following elements: lithium, sodium, potassium, rubidium, caesium, copper, calcium, strontium, barium, and magnesium.

Frequency differences of doublets in the spectra of sodium, potassium, rubidium, caesium, and copper are shown to be constant in most cases to one part in 100,000 in the number of waves per centimeter.

W. F. M.

GEOLOGY.—*Chemical relations of the oil-field waters in San Joaquin Valley, California.* G. SHERBURNE ROGERS. U. S. Geological Survey Bulletin 653. Pp. 119. 1917.

The chief conclusions concerning the chemistry of the waters, deduced from a study of several hundred analyses of water from different depths, are as follows:

1. Oil-field water is not necessarily salty, as is generally believed, and may not be even slightly salty to the taste. The degree of concentration of chloride in such water is governed primarily by local conditions and is not affected by the position of the water in relation to oil.

2. Sulphate, which predominates in most of the shallow ground waters on the west side of San Joaquin Valley, diminishes in amount as the oil zone is approached and finally disappears.

3. The concentration of carbonate increases as the oil zone is approached but depends largely on the concentration of chloride.

4. The horizon, with respect to the oil zone, at which these alterations take place, is different in each field.

On the basis of these conclusions, which appear to be well grounded, at least for the area studied, the following practical suggestions may be made:

In drilling a well in untested territory it may be possible to obtain an indication of the presence or absence of oil and gas below by ascertaining by analysis whether the sulphate is diminishing and the carbonate increasing in the waters successively encountered. In some areas a significant change may be detected as much as 1,000 feet above the oil; in others the upper limit of alteration may be within a few hundred feet of the oil.

The source of the water in a well that produces a mixture of water and oil may be determined, at least in a general way, by studying its chemical composition. In the Westside Coalinga field, for example, the source of the water may thus be determined rather definitely; in the Midway-Sunset field, where the distinctions are less sharp, the success of this method will depend largely on the number of authentic analyses that are available for comparison. G. S. R.

GEOLOGY.—*Manganese deposits of the Caddo Gap and De Queen quadrangles, Arkansas.* HUGH D. MISER. U. S. Geological Survey Bulletin 660-C. Pp. 64. 1917.

The manganese deposits of the Caddo Gap and De Queen quadrangles in west-central Arkansas comprise those that are at present being most extensively exploited. They have been worked on a small scale only and have yielded but a few hundred tons of marketed ore. They occur in the Arkansas novaculite of Devonian age and are mainly confined to two stratigraphic horizons, one being near the top and the other near the middle of the formation. The novaculite, together with the other formations, has been closely folded and its outcropping edges stand up as parallel, nearly eastward-trending ridges on which rock ledges or their dèbris abound. The manganese ores consist of oxides,—psilomelane, pyrolusite, and manganite being most abundant. Although these minerals may be found separately, as a rule two or more are intimately mixed in the same deposit, and in some places they are associated with iron oxides and manganiferous iron ores. The manganese ores occur as nodules, pockets, and short irregular veins from a fraction of an inch to 4 feet thick. Thicknesses of 4 feet, however, are rare, and those of a foot are not common. The ores occupy bedding planes or joint cracks or form a cement in novaculite breccia.

Most of the manganese was probably deposited originally as finely disseminated particles with the silica that formed the novaculite, a rock that is regarded as belonging to the class of charts; the rest of the manganese may have been deposited in disseminated form in the overlying and underlying shales. Its concentration has been effected by ground water, which has carried it down from the vast mass of rock that has been eroded from the region; and its localized concentration into deposits large enough to be of value appears to have been dependent upon the amount of open space in the novaculite, which is hard and compact and usually has no visible openings between the layers or along the joints. Faults and the ends of plunging anticlines, as is attested by a number of deposits occurring in such places, were favorable places for the accumulation of ore.

Most of the ores contain too much phosphorus for the manufacture of ferromanganese. They usually contain too much iron for use in chemical industries and electric batteries, and, where the quality is suitable for these purposes, the quantity is generally too small for profitable mining. The quantity of ore that can be mined at a profit from any one deposit is small. H. D. M.

ORNITHOLOGY.—*Notes on the fringilline genus Passerherbulus and its nearest allies.* Harry C. Oberholser. Ohio Journ. Sci. **17**: 332–336. June 2, 1917.

A careful examination and comparison of the species of *Passerherbulus* at once discloses the fact that this genus as at present constituted is a composite group. It is, therefore, here separated into four genera. The seaside sparrows, six in number, are given the name *Thryospiza* gen. nov., with *Fringilla maritima* Wilson as the type. For *Passerherbulus caudacutus* and its two subspecies the generic name *Ammospiza* Oberholser is used. The Nelson sparrow (*Ammodramus caudacutus nelsoni* Allen) and the Acadian sharp-tailed sparrow (*Ammodramus caudacutus subvirgatus* Dwight) prove now by examination of more material to be both subspecies of *Ammospiza caudacuta* (Gmelin). The genus *Passerherbulus* is here restricted to *Passerherbulus leconteii* (Audubon); and for *Emberiza henslowii* Audubon and its western subspecies the new genus *Nemospiza* is proposed. H. C. O.

ORNITHOLOGY.—*The status of Aphelocoma cyanotis and its allies.* Harry C. Oberholser. The Condor **19**: 94–95. May, 1917.

The blue-eared jay, *Aphelocoma cyanotis* Ridgway, was originally described from Mexico and has since been reported from Texas. The Texas birds, however, prove to belong to *Aphelocoma texana;* and *Aphelocoma cyanotis* is therefore restricted to Mexico. Although heretofore regarded as distinct species, *Aphelocoma cyanotis*, *Aphelocoma texana*, *Aphelocoma sumichrasti*, and *Aphelocoma woodhouseii* are all now discovered to be geographic races of *Aphelocoma californica*. Incidentally the bird described by Dr. Joseph Grinnell as *Aphelocoma californica immanis* from southern Oregon is reinstated. H. C. O.

ORNITHOLOGY.—*The birds of Culebra Island, Porto Rico.* Alexander Wetmore. The Auk **24**: 51–62. January, 1917.

This is the first published list of the birds of the Island of Culebra, and is based largely on observations made and the specimens collected by the author from April 4 to 22, 1912. The number of species here recorded from the island is 54, including one of doubtful status, a good proportion of which are considered resident species. None are, however, peculiar to Culebra Island. Notes on habits are added under many of the species. H. C. O.

ORNITHOLOGY.—*Description of a new genus of Anatidae.* HARRY C. OBERHOLSER. Proc. Biol. Soc. Washington **30**: 119–120. May 23, 1917.

The rare Laysan teal, *Anas laysanensis* of authors, interesting on account of its limited island distribution, is found to differ decidedly in structural characters from any genus of ducks hitherto recognized, and is here made the type of a new genus, *Horizonetta*. H. C. O.

ORNITHOLOGY.—*Notes on North American birds. I.* HARRY C. OBERHOLSER. The Auk **34**: 191–196. April, 1917.

This is the first of a series of articles on the status, relationships, and nomenclature of various North American birds. The present installment treats of seven species and subspecies. The specimen of *Cepphus snowi* Stejneger, said to have been taken on the Kenai River, Alaska, proves to be, owing to the possibility of transposition of labels, very doubtfully North American. A specimen of the South American *Dendrocygna viduata* killed in New Jersey, and recorded as an addition to the North American fauna, seems undoubtedly to be a bird that has escaped from captivity, and as such not entitled to a place in our fauna. The status of the forms of *Anas rubripes* is discussed and the conclusion reached that both *Anas rubripes rubripes* and *Anas rubripes tristis* are recognizable subspecies, the former breeding from northern Ungava to Hudson Bay, and the latter from Maryland and Newfoundland west to Wisconsin. The form of California partridge inhabiting Santa Catalina Island, California, originally described as *Lophortyx catalinensis* Grinnell, is reinstated as a subspecies of *Lophortyx californica*. The Florida race of *Myiarchus crinitus* and the American robin breeding on the Pacific Coast from the northwestern United States to southern Alaska are both considered tenable subspecies and revived to stand as *Myiarchus crinitus residuus* Howe and *Planesticus migratorius caurinus* Grinnell, respectively. H. C. O.

ORNITHOLOGY.—*Description of a new Sialia from Mexico.* HARRY C. OBERHOLSER. Proc. Biol. Soc. Washington **30**: 27–28. February 21, 1917.

A new and unexpected form of the eastern bluebird is here described as *Sialia sialis episcopus*, from specimens taken at Santa Engracia, Tamaulipas, northeastern Mexico. It presents a combination of the characters of *Sialia sialis sialis* and *Sialia sialis fulva*. It proves to be also the breeding bluebird of the lower Rio Grande region in Texas. H. C. O.

ORNITHOLOGY.—*Critical notes on the eastern subspecies of Sitta carolinensis Latham.* HARRY C. OBERHOLSER. The Auk 24: 181–187. April, 1917.

Although the white-breasted nuthatch of the eastern United States has been recently divided into three forms, careful investigation now shows that only two, a northern and southern, are recognizable. The race from Florida, hitherto called *Sitta carolinensis atkinsi*, must now be known as *Sitta carolinensis carolinensis* Linnaeus, since birds from the type locality of the latter, South Carolina, are referable to the Florida form. The recently described *Sitta atkinsi litorea* of Maynard, from the coast region of southern North Carolina, consequently becomes a synonym. True *Sitta carolinensis carolinensis* therefore ranges from Florida and Louisiana north to southern North Carolina and southern Illinois. The bird of the northeastern United States, from northern Illinois and northern North Carolina northward into southern Canada, heretofore called *Sitta carolinensis carolinensis*, becomes therefore nameless and is here christened *Sitta carolinensis cookei*. H. C. O.

ORNITHOLOGY.—*A synopsis of the races of Bombycilla garrula (Linnaeus).* HARRY C. OBERHOLSER. The Auk 24: 330–333. July, 1917.

The Bohemian waxwing, which occurs in northern North America, northern Asia, and northern Europe, although heretofore supposed to be undifferentiated into geographic races, is found to be made up of three recognizable subspecies. These are *Bombycilla garrula garrula* (Linnaeus), from Europe; *Bombycilla garrula centralasiae* Poljakov, from central and northern Asia; and *Bombycilla garrula pallidiceps* Reichenow, from North America. The North American representative proves to be a well-marked form. H. C. O.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

BOTANICAL SOCIETY OF WASHINGTON

The 122d regular meeting of the Botanical Society of Washington was held at the Cosmos Club, Tuesday, October 2, 1917, at 8 p.m. Thirty-one members were present. The following scientific program was given:

Need for textile plant fibers (Illustrated with lantern slides): LYSTER H. DEWEY. The speaker presented for the inspection of the audience samples of the fiber produced from different plants, such as flax, hemp, jute, and henequén, and showed slides illustrating the culture of these crops and the operations necessary for separating the fiber therefrom. The following conclusions were announced by the speaker: The reduced production of flax and hemp in Russia, and jute in India, combined with difficulties of transportation and increased consumption of certain fibers, has resulted in demands greatly in excess of supplies.

Flax is not now regarded as absolutely necessary for tablecloths and napkins, and it has long since given place to cotton in most of the so-called linen collars and shirts, but it is demanded in the wings of airplanes, and must be used largely in shoe thread. Ireland's 107,000 acres of flax, double the area devoted to this crop in pre-war years, and the marked increase up to 39,000 acres in Japan are helping out the supplies, while hemp and cotton are used more than ever before as substitutes.

Hemp is in demand as indicated by the increase in the price from about 6 cents per pound before the war to 16 cents per pound now. The usual supplies of Russian hemp and Italian hemp have been cut down, while the prices for these imported hemps have gone up 300 per cent. Hemp is used for commercial twines, fishing lines, nets, packing, and oakum, and it is now being dressed like flax and made into shoe thread. The reduced supply of imported hemp is more than counterbalanced by the increased supply of hemp grown in this country, the acreage increasing from 4000 in 1914 to more than 41,000 in 1917.

Jute is normally used in greater quantity than any other fiber except cotton, and in addition to its use for covering cotton, wool, grain, sugar, coffee, cement, and many other articles in transit it is now in demand for sand bags in the trenches. Practically all of the jute of the world's supply comes from India. The crops of the last two years have been below the normal consumption, and this, added to the very serious difficulties of transportation, has resulted in shortage of supply and

advanced prices. The most promising substitute for jute is low-grade hemp and flax.

More publicity has been given to the shortage of henequén (Yucatan sisal) for binder twine than to most other fibers. Reports from Yucatan, where most of this fiber is produced, and also from other regions where sisal, Manila maguey, and other substitutes suitable for binder twine are produced, indicate that with reasonable economy there will be twine enough for the grain crop next season. The present high prices are inducing the establishment of sisal and henequén plantations in many parts of the Tropics, but it will take five years or more for most of these plantations to reach the stage of production. Until that stage is reached hemp grown in the United States offers the most promising solution of the binder-twine problem. Fibers from various kinds of yuccas, dasylirions, and sansevierias have been suggested, but, besides being poorly adapted for the purpose, no satisfactory method has been developed for preparing them, and with present demands on all well-equipped machine shops this is no time for the development of experimental machinery.

This shortage of supplies of fiber has one bright side. It has persuaded American spinners to appreciate the possibilities of American-grown fiber as they have never done before.

The 17th annual business meeting of the Society was held in connection with the 122d regular meeting as announced above. The report of the Executive Committee showed the following facts concerning the activities of the Society for the preceding year: Average attendance, forty-nine members and fourteen guests. Fifteen new members were elected, making a total membership of one hundred and sixty-three. The customary reports were presented and approved, and the following officers elected for the ensuing year: *President,* WALTER T. SWINGLE; *Vice President,* J. W. T. DUVEL; *Recording Secretary,* CHAS. E. CHAMBLISS; *Corresponding Secretary,* H. N. VINALL; *Treasurer,* F. D. FARRELL. The retiring president, T. H. KEARNEY, was nominated as the representative of the Society upon the Board of the Washington Academy of Sciences.

H. N. VINALL, *Corresponding Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 792d meeting was held at the Cosmos Club, October 13, 1917. Vice President HUMPHREYS in the chair, 127 persons present.

By invitation Mr. R. A. MILLIKAN delivered a paper on *The organization of scientific effort in relation to the war.*

Mr. G. K. BURGESS gave a paper on *The application of science to warfare in France.*

Discussion: The papers were discussed by Messrs. LITTLEHALES, L. J. BRIGGS, and KILLIAN.

DONALD H. SWEET, *Secretary.*

REPRINT OF HEREDITY LECTURES

A series of three public lectures by Prof. H. S. Jennings, Dr. Oscar Riddle, and Prof. W. E. Castle, dealing with the subject of heredity, was given under the auspices of the Washington Academy of Sciences during March and April, 1917. In view of the wide-spread interest in the lectures, and in response to numerous requests, the Academy has reprinted in collected form a limited edition of the lectures as published in the JOURNAL.

Copies of the brochure, substantially bound in flexible cloth covers, may be purchased of the Treasurer, Mr. William Bowie, Coast and Geodetic Survey, Washington, D. C., at fifty cents each (postage included).

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Tuesday, November 20: The Anthropological Society, at the National Museum, at 4.30 p.m. Program:

GEORGE J. ZOLNAY: *Roumania, past and present.*

Tuesday, November 20: The Society of Engineers, at Rauscher's, 1034 Connecticut Ave., NW., at 8 p.m.

Saturday, November 24: The Philosophical Society, at the Cosmos Club, at 8 p.m. Program:

H. E. MERWIN and L. H. ADAMS: *Polymorphism of the oxides of lead.* 20 minutes.

G. W. MOREY and E. D. WILLIAMSON: *Quantitative applications of the phase rule.* 30 minutes.

Wednesday, November 28: The Geological Society, at the Cosmos Club, at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and the twenty-seventh day of each month.

CONTENTS

ORIGINAL PAPERS

Page

Physics.—Criteria for gray radiation. PAUL D. FOOTE 573

Geology.—Clay derived from volcanic dust in the Pierre in South Dakota. EDGAR T. WHERRY 576

ABSTRACTS

Geodesy 584
Physics 584
Geology 586
Ornithology 586

PROCEEDINGS

Botanical Society 591
Philosophical Society 592

Vol. VII

No. 20

December 4, 1917

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

Manuscripts may be sent to any member of the Board of Editors; they should be clearly typewritten and in suitable form for printing without essential changes. The editors cannot undertake to do more than correct obvious minor errors. References should appear only as footnotes and should include year of publication.

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* Volume I, however, from July 19, 1911, to December 19, 1911, will be sent for $3.00. Special rates are given to members of scientific societies affiliated with the Academy.

THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. VII DECEMBER 4, 1917 No. 20

PHYSICS.—*Anode resistance films.* JOHN T. TATE and PAUL D. FOOTE, Bureau of Standards.

In a previous paper[1] it was concluded that a polarization film of high resistance forms at the surface of a probe placed in the anode glow of a Wehnelt discharge tube. In the measurements referred to, the probe wire acted as an anode. It is of interest to compare the film resistance when the probe acts as an anode with that obtained when the probe acts as a cathode.

The experimental arrangement was that illustrated in the paper already referred to. For the probe as anode the same electrical connections were employed. For the probe as cathode the potentiometer and voltmeter readings were taken between the probe and the Wehnelt cathode. Resistances were computed in the manner previously described. The results of one series of measurements are represented by figure 1. For the same current flowing through the probe the film resistance is 4 to 6 times greater when the probe acts as a cathode than when it acts as an anode. The ratio of resistances $R_{\text{cathode}} : R_{\text{anode}}$ increases with increasing current through the probe. It has been generally assumed that the anode resistance film is negligible in magnitude as compared with the cathode resistance film. The small values of the ratio R_c/R_a observed are therefore of interest. It is also of interest to note that the ratio of the resistances of the cathode and anode films is of the same order of

[1] This JOURNAL 7: 482. 1917.

magnitude as the ratio of the cathode and anode falls of potential. The anode fall is usually about 20 volts and the cathode fall around 150 to 200 volts.

Further measurements were made upon anode resistance films in order to determine whether the resistance is inversely propor-

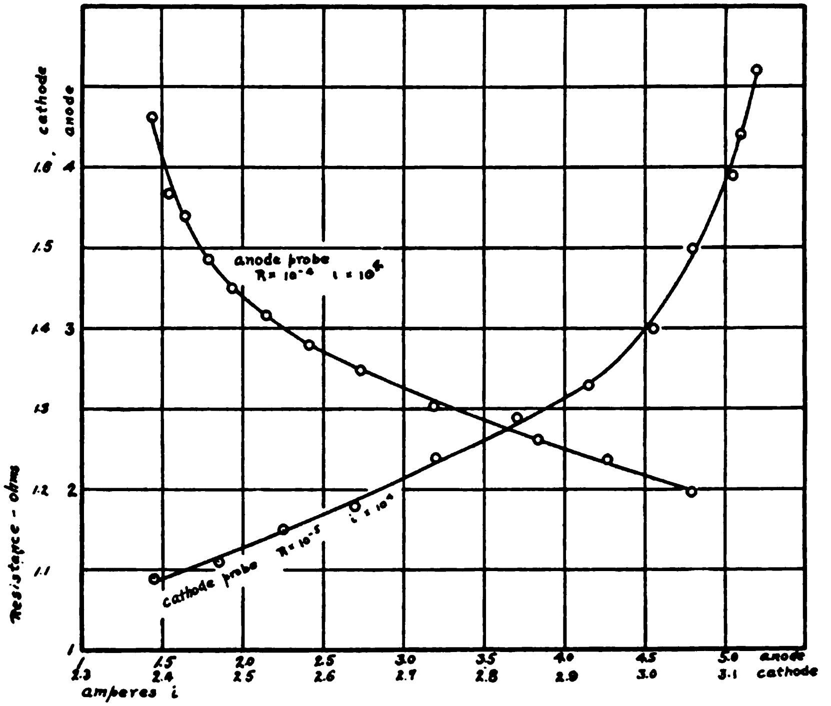

Fig. 1. Relation between surface resistance and current for probe acting as anode and as cathode.

tional to the area, a relation which would follow if the films acted as ordinary resistances. Two probe wires of the same diameter and having exposed areas in the ratio 1:2.28 were used in the place of R_p (fig. 1, p. 483). These could be operated as secondary anodes, either separately or shunted together. The resistances, R_1 of probe 1, R_2 of probe 2, and R_{1+2} of probes 1 and 2 connected, were measured in the manner previously described. The results of these measurements made with various current densities are given in table 1.

By the ordinary law of shunt resistances, if $R_1/R_2 = 2.3$ then R_1/R_{1+2} should equal 3.3, in agreement with the experimentally determined value. The ratio of areas of probes 1 and 2 was 1:2.28 while the observed ratio of resistances R_1/R_2 was 2.3:1. Hence the resistance of the polarization film varies inversely as its area.

TABLE 1

ANODE FILM RESISTANCE

R_1	R_2	R_{1+2}	R_1/R_2	R_1/R_{1+2}
ohms	*ohms*	*ohms*		
21,980	9,980	7,780	2.2	2.8
25,900	11,650	8,380	2.2	3.1
29,200	9,260	8,200	3.1	3.6
29,800	13,300	8,950	2.2	3.3
26,200	16,500	12,500	1.5	2.1
32,500	13,500	13,500	2.4	2.4
40,000	16,700	8,800	2.4	4.5
35,800	12,800	12,000	2.8	3.0
33,500	19,000	7,300	1.8	4.6
41,500	15,200	12,000	2.7	3.5
26,900	11,250	7,720	2.4	3.5
26,750	14,200	9,900	1.9	2.7
Mean....................................			2.3	3.3

Conclusions. Further experimental work has confirmed the existence of an anode polarization film. The resistance of the anode film is less than that of the cathode film, and the two types of polarization resistance appear to be in a ratio of about the same order of magnitude as the ratio of anode to cathode fall of potential. The resistance of the anode film varies inversely with its area, but it should be emphasized that this relation was tested for wires of the same diameter. On account of changes which would be produced in the character of the field it is probable that the relation would not hold for wires of different diameters. Skinner has found entirely different values of resistance per square centimeter for wires of different diameters.

MINERALOGY.—*Tungstenite, a new mineral.*[1] By R. C. Wells and B. S. Butler, Geological Survey.

Although two sulphides of tungsten are described in text-books of chemistry, none has hitherto been found as a mineral. It is therefore a pleasure to announce the discovery of tungsten sulphide as a prominent mineral in certain specimens of ore from the Little Cottonwood district, Utah. The analysis of the complex mixture in which tungsten sulphide occurs has proved unexpectedly difficult, so that it is not yet possible to state definitely the formula of the sulphide, although it is believed to be WS_2. As it will require considerable time to complete the necessary analytical determinations it seems advisable, in view of the unusual character of the material, to publish our preliminary results at this time. On account of the apparent resemblance to molybdenite in formula and some of its properties the new mineral has been named *tungstenite.*

The material in which tungstenite was found was given to Mr. V. C. Heikes, of the Salt Lake City office of the United States Geological Survey, by Mr. J. J. Beeson, geologist for the Emma Consolidated Copper Company, of Little Cottonwood district, Salt Lake County, Utah, with the suggestion that it be tested for selenium. Mr. Heikes forwarded the material to one of the writers (B. S. B.), who has been engaged in geological work in the district and who later, with F. C. Calkins, examined the deposit from which it came, though this was before the character of the mineral had been determined. The chemical examination and recognition of the tungsten sulphide was by the other writer (R. C. W.). No selenium could be determined, but on treating some of the material with aqua regia a yellow insoluble powder was noted and identified as tungstic oxide. Further study indicated that the tungsten is present as sulphide very intimately associated with a number of other minerals.

The Emma mine, from which the material was obtained, is located in the Little Cottonwood district, Salt Lake County, Utah, about 25 miles southeast of Salt Lake City. The mine was

[1] Published with the permission of the Director of the United States Geological Survey.

an important producer of lead-silver ores in the seventies. The ore shoot was followed until it was cut off by a fault. Attempts at the time to locate the continuation beyond the fault were unsuccessful and the mine was idle for many years. In 1916 Mr. Beeson by a detailed geologic study procured data that in 1917 led to the finding of the extension of the ore shoot. It was from this extension below the oxidized zone that the material here described was obtained.

TABLE 1

CHEMICAL ANALYSIS OF TUNGSTENITE (BY R. C. W.)

	PER CENT	FOR TENNANTITE AND TETRAHEDRITE	FOR PYRITE	FOR GALENA	FOR TUNGSTENITE	ATOMIC RATIO
W	44.7				44.7	1.00
S	29.1	2.5	9.2	0.6	16.8	2.18
Fe	8.8	0.8	8.1			
Zn	0.4	0.4				
Mn	0.6	0.6				
Ni	0.3	0.3				
Pb	4.1			4.1		
As	1.0	1.0				
Sb	0.8	0.8				
Cu	1.3	1.3				
Ag	0.4	0.4				
SiO_2	0.3					
H_2O	0.7					
Undetermined	7.5					
	100.0	8.1	17.3	4.7	61.5	

Two specimens of the material were examined chemically. The first specimen contained a much slickensided substance resembling graphite intimately associated with quartz, calcite, pyrite, gelena, and various accessory minerals. Tungstenite was identified in the slickensided material but it was not the only mineral present. The second specimen appeared to be much purer than the first and an average sample of it was analyzed with the results shown in table 1. This specimen was of a uniform gray color where it had been broken from a larger piece, but two sides were somewhat slickensided. On close examination

abundant small somewhat rounded grains of pyrite could be detected in it. A polished section revealed a little galena also. The analysis indicates tennantite and tetrahedrite, which were not distinguished in the single polished section of the material examined. A portion of the polished section which had a slightly bluish tinge was identified by microscopic reaction as tungstenite. The tungstenite is so soft that it wears away much faster than pyrite during polishing. The hardness appears to be about 2.5. Particles which are very easily cut from the massive piece with a knifeblade appear under the microscope to consist of feathery leaves or flakes resembling graphite. The mineral is opaque. It marks paper, soils the fingers slightly, and rubs up between a mortar and pestle like graphite. The cleavage and fracture could not be determined. The luster varies from dull to brilliant metallic; the color is dark lead gray; and the streak is dark gray. The actual specific gravity of the second specimen mentioned was 6.43. Allowing as well as possible for the impurities and undetermined material, the specific gravity of the tungstenite is calculated to be about 7.4. This may be compared with the following specific gravities, MoS_2 4.7, FeS_2 4.9, MoO_3 4.5, WO_3 6.3.

Tungstenite appears to be unattacked by hydrochloric acid or nitric acid. It is decomposed by aqua regia or by fusion with sodium nitrate. Its behavior in a bulb tube and on charcoal can not be stated definitely because of the impurities, though it appears to be a rather stable compound, not even being oxidized, by roasting in air. It burns with incandescence in oxygen.

Tungsten was determined by decomposing the ore with aqua regia. The solution was evaporated to dryness and the insoluble material taken up in dilute hydrochloric acid and filtered off. After extracting it with ammonium acetate to remove any lead sulphate present it was heated with ammonium hydroxide. A few per cent of residue remained insoluble in ammonia and contained some tungstic oxide, a little silica, some iron, and other material not yet determined. The filtered ammoniacal solution was evaporated to dryness and the residue was ignited and weighed as tungstic oxide. The other constituents were determined as in the analysis of tetrahedrite, after decomposing a portion of

the ore with chlorine in a hot tube. As the analysis stands the sample analyzed consists of 8.1 per cent of tennantite and tetrahedrite, 17.3 per cent of pyrite, 4.7 per cent of galena, and 61.5 per cent of tungstenite.

The geology of the district in which tungstenite has been found may be briefly summarized as follows: A series of Paleozoic limestones, shales, and quartzites, and pre-Paleozoic quartzites and shales, has been much broken by thrust faulting and subsequently intruded by quartz monzonite and quartz diorite which occur as stocks. Following the intrusion and accompanying mineralization there was much normal faulting and some reverse faulting.

The Emma ore body occurs as a replacement of a brecciated zone in Paleozoic limestone where it is crossed by a mineralizing fissure. The ore shoot follows the intersection of the breccia zone and fissure, pitching rather steeply to the northeast. About 450 feet below the outcrop the ore shoot is cut off by a strong fault, the continuation on the opposite side of the fault being about 250 feet lower. There is very little oxidized material in the portion of the shoot below the fault from which the tungstenite was taken.

The important vein minerals are quartz, galena, pyrite, tetrahedrite, argentite, and possibly some other silver minerals not yet determined. The detailed study of the ores will probably reveal other minerals. For a part of the shoot at least, the central portion consists mainly of rather fine-grained quartz that has almost completely replaced the limestone and that contains but relatively small amounts of metallic minerals. Surrounding this is a zone in which the limestone is less completely replaced and metallic minerals are more abundant.

Pyrite was the earliest metallic mineral to form in the deposit and this was followed by the galena, tetrahedrite, silver minerals, and tungstenite. The tungstenite is apparently in part contemporaneous with the galena and in part later than the galena. The fact that the specimens containing the most of this mineral have been found near a minor faulted zone suggests that there may have been an enrichment in tungsten along that zone, though that is not certain.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this JOURNAL and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Hydraulic-mining débris in the Sierra Nevada.* GROVE KARL GILBERT. U. S. Geological Survey Professional Paper 105. Pp. 154, with maps, sections, and illustrations. 1917.

Historical outline is given of the development of hydraulic mining in the Sierra Nevada, the encroachment of its tailings on valley lands, its subsequent restriction and regulation, and the circumstances leading to a study of the subject by the Geological Survey.

The tailings from hydraulic mines were in part deposited on neighboring slopes and in neighboring stream valleys and canyons and in part delivered to rivers that carried them forward. At the base of the range were large deposits on the piedmont slopes and other deposits in the beds of valley rivers. As a consequence of the piedmont and river-bed deposits rivers rose higher in time of flood and lands previously immune were inundated. The reclamation of basin lands and delta lands for agriculture by surrounding them with levees also aggravated flood conditions, and the results of the two causes were inseparable.

Comparison of maps of early and late dates shows that large deposits have shoaled the bays of the San Francisco system, and reduced their areas. These deposits, ascribed to hydraulic mining and to the increase of soil waste by agriculture and other industries, since the discovery of gold have amounted to more than 1100 million cubic yards.

The sand brought to the head of Suisun Bay by Sacramento and San Joaquin rivers is swept onward in the bays by tidal currents but is not believed to reach the Golden Gate bar in any appreciable quantity.

The stress that caused the restriction of hydraulic mining no longer exists. Under conditions to be created by works for the control of floods the capacity of valley rivers for transportation of débris will be increased, so that the mining might be partly resumed without preju-

dice to any valley interest except navigation. The important interest which now dictates that débris should be controlled is that of the commerce which traverses the Golden Gate. Possibilities for resumption of mining on a large scale, with storage of débris, lie in cooperation with irrigation and electric-power development for the control of Sierra streams. R. W. STONE.

GEOLOGY.—*Geologic history indicated by the fossiliferous deposits of the Wilcox group (Eocene) at Meridian, Mississippi.* EDWARD WILBER BERRY. U. S. Geological Survey Professional Paper 108-E. Pp. 12, with 2 plates and 2 figures. 1917.

This paper discusses briefly new and important additions to the flora of the Wilcox group and new evidence of the unconformity between the Wilcox and the Claiborne groups.

The conclusion seems justified that the upper Wilcox was a time during which the open sea became gradually smaller as the strand line moved southward, and that there was an interval of emergence between the deposition of the Wilcox and that of the Claiborne group, an interval whose considerable length is indicated by the great contrasts between the terrestrial floras and the marine faunas of the Wilcox and the Claiborne.

The two new species described are of especial interest in that the Nelumbo adds an entirely new type to the Wilcox flora, and the second adds a new cycad (Zamia), represented by fronds, the only known cycad from the American Tertiary except a single piece of a pinnule of another species of Zamia from the Wilcox. R. W. STONE.

GEOLOGY.—*A fossil flora from the Frontier formation of southwestern Wyoming.* F. H. KNOWLTON. U. S. Geological Survey Professional Paper 108-F. Pp. 35, with 13 plates. 1917.

This paper deals with a small but important fossil flora, now known to be of Colorado age, from the vicinity of Cumberland, Lincoln County, Wyoming. Although small in number of species, this flora offers information bearing on the physical and climatic conditions that prevailed in this region during early Upper Cretaceous time. It has also a possibly important biologic bearing, for it shows the presence of certain plant types that are now living in Polynesia. The plants described occur in what is now known as the Frontier formation.

The known flora from the Frontier formation near Cumberland embraces 25 forms, of which 7 are ferns, 1 an Equisetum, 1 a monocotyle-

don (Smilax), and the remaining 16 dicotyledons. They are entirely unlike anything now living in the New World and appear to find their closest relatives among species now living in Polynesia.

From the facts now available it appears unquestionable that at least the major portion of the Frontier formation was laid down in fresh water. The climate during Frontier time appears to have been tropical or subtropical. R. W. STONE.

GEOLOGY.—*The Bull Mountain coal field, Musselshell and Yellowstone counties, Montana.* L. H. WOOLSEY, R. W. RICHARDS, and C. T. LUPTON. U. S. Geological Survey Bulletin 647. Pp. 218, with maps, sections, and illustrations. 1917.

The Bull Mountain coal field came into prominence about 1906, when the westward extension of the Chicago, Milwaukee & St. Paul Railway was constructed through this part of Montana. This field is the chief source of fuel for this new transcontinental road and in consequence has been developed very rapidly, especially in the vicinity of Roundup.

The important coal-bearing formation is the Fort Union, which belongs to the lower part (Eocene series) of the Tertiary system. The rocks of this formation consist principally of massive, buff to yellowish-gray sandstone and light-colored clay shale. The lower 200 to 300 feet of the formation contains little coal.

The lowest formation outcropping in the Bull Mountain field is the marine Bearpaw shale, which is recognized in this part of Montana as the upper formation of the Montana group. The Lance formation overlies the Bearpaw shale and appears to be in conformable sequence with it. The Lance formation consists of alternating beds of yellowish-gray sandstone, drab, yellow, and gray clays, clay shale, and grayish sandy shale. Sandy material predominates. The lower part of the formation is noticeably micaceous; the upper part contains thin beds of coal.

The strata 200 to 300 feet thick immediately overlying the Lance and apparently conformable both with the Lance below and the upper part of the Fort Union above are known as the Lebo shale member. The member is conspicuous on account of its dark or olive-green color and the absence of the resistant sandstone which characterizes the overlying beds of the upper part of the Fort Union and the underlying Lance formation.

The upper part of the Fort Union formation occupies all of the center of the Bull Mountain region and contains the principal coal beds. It is composed of sandstone in beds ranging from a fraction of a foot to 50 feet or more in thickness, interbedded with a somewhat larger proportion of clay shale, shale, and numerous beds of coal.

Within the upper part of the formation there are 26 coal beds, ranging in thickness from 1 foot 2 inches to 15 feet. From the abundance of fossil leaves and fresh-water shells and the numerous beds of coal it is evident that the formation was deposited in fresh or nearly fresh waters, probably inland lakes or ancient estuaries on whose shores grew luxuriant vegetation.

All coal in this field may be classed as high-grade black lignite or subbituminous. Most of the coal beds are lenticular, showing a wide variation in thickness at different points on the outcrop. The coal beds are described and analyses given. The greater part of the volume is detailed description of the geology by townships. R. W. Stone.

GEOLOGY.—*Mineral resources of the Kantishna region, Alaska.* S. R. Capps. U. S. Geological Survey Bulletin 662–E. Pp. 53, with maps, sections, and illustrations. 1917.

The region discussed lies on the north side of the Alaska Range and includes portions of the basins of Nenana and Kantishna rivers.

The rocks of the Kantishna region range from highly metamorphic mica schists and gneisses, through less altered but deformed sediments of Paleozoic age, to the slightly indurated Tertiary coal-bearing beds and to the unconsolidated terrace gravels and the deposits of present streams.

The prevailing structural trend of the region is east-northeast, parallel to the axis of the Alaska Range, and has been determined by movements similar to those which brought the present range into existence.

The productive gold placer deposits of the Kantishna district all occur in the basins of the streams that head in the Kantishna Hills and radiate in all directions from the higher peaks. Paying deposits of gold placer gravel were found in 1905 and 1906 on all the streams that are now productive except Little Moose Creek.

The entire Kantishna mining district lies in an area in which the underlying rock is the Birch Creek schist, cut by relatively small bodies of intrusive rocks. Among these intrusives are some dikes and

stocks of granite prophyry and quartz porphyry that may be genetically related to the mineralized quartz veins. The largest and most continuous gold-bearing quartz veins that have been found are in the basins of those streams whose placers have yielded the most gold. This seems to be conclusive proof that the gold of the placer gravels was derived, at least in large part, by the erosion of the larger quartz veins that cut the schists. The local origin of the placer gold is also confirmed by the appearance of the gold itself.

In those portions of the region that were glaciated the erosion by the ice was sufficiently severe to disturb or remove the greater part of the preexisting gold placer deposits, so that any concentrated deposits of gold that are now present are due to the erosion by streams since the ice retreated.

A fact that has notably influenced the gold placer deposits in many valleys is the large volume of detrital material that has moved from the valley walls down the slopes and out upon the stream gravel deposits and the rapidity with which this movement takes place.

R. W. Stone.

GEOLOGY.—*Tungsten minerals and deposits.* Frank L. Hess. U. S. Geological Survey Bulletin 652. Pp. 85, with maps, sections, and illustrations. 1917.

An attempt is made to gather into this bulletin the general facts about tungsten, the minerals in which it is found, the kinds of deposits from which these minerals are obtained, and other information, and to show by illustrations, colored and uncolored, the appearance of typical specimens of the various tungsten minerals.

Tungsten deposits seem to be invariably in or associated with granitoid rocks, though they may be associated with their prophyritic facies, and, so far as is known, only with the varieties that contain considerable quantities of free quartz, and usually if not always with the lighter-colored members.

Most of the tungsten deposits of the country are in the states that lie in and west of the Rocky Mountains—South Dakota, Montana, Colorado, New Mexico, Idaho, Utah, Arizona, Nevada, California, Oregon, and Washington—all of which contain at least small deposits. Wyoming is the only state in this whole great western area in which no tungsten is known to have been found.

R. W. Stone.

REPRINT OF HEREDITY LECTURES

A series of three public lectures by Prof. H. S. Jennings, Dr. Oscar Riddle, and Prof. W. E. Castle, dealing with the subject of heredity, was given under the auspices of the Washington Academy of Sciences during March and April, 1917. In view of the wide-spread interest in the lectures, and in response to numerous requests, the Academy has reprinted in collected form a limited edition of the lectures as published in the JOURNAL.

Copies of the brochure, substantially bound in flexible cloth covers, may be purchased of the Treasurer, Mr. William Bowie, Coast and Geodetic Survey, Washington, D. C., at fifty cents each (postage included).

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Saturday, December 8: The Philosophical Society, at the Cosmos Club, at 8 p.m. Program:
Annual meeting and election of officers.

Wednesday, December 12: The Geological Society, at the Cosmos Club, at 8 p.m. Program:
Presidential address, followed by the annual meeting.

Tuesday, December 18: The Anthropological Society, at the National Museum, at 4.30 p.m.

Tuesday, December 18: The Society of Engineers, at Rauscher's, 1034 Connecticut Ave., NW., at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and the twenty-seventh day of each month.

CONTENTS

ORIGINAL PAPERS

Page

Physics.—Anode resistance films. JOHN T. TATE and PAUL D. FOOTE.... 593

Mineralogy.—Tungstenite, a new mineral. R. C. WELLS and B. S. BUTLER 596

ABSTRACTS

Geology.. 600

VOL. VII

DECEMBER 19, 1917

No. 21

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST, AND SEPTEMBER, WHEN MONTHLY

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
WILLIAMS & WILKINS COMPANY
BALTIMORE, MD.

Entered as second-class matter July 14, 1911, at the post office at Baltimore, Maryland, under the Act of July 16, 1894

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, aims to present a brief record of current scientific work in Washington. To this end it publishes: (1) short original papers, written or communicated by members of the Academy; (2) a complete list of references to current scientific articles published in or emanating from Washington; (3) short abstracts of certain of these articles; (4) proceedings and programs of meetings of the Academy and affiliated Societies; (5) notes of events connected with the scientific life of Washington. The JOURNAL is issued semi-monthly, on the fourth and nineteenth of each month, except during the summer when it appears on the nineteenth only. Volumes correspond to calendar years. Prompt publication is an essential feature; a manuscript reaching the editors on the second or the seventeenth of the month will ordinarily appear, on request from the author, in the next issue of the JOURNAL.

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THE WAVERLY PRESS
BALTIMORE, U. S. A.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. VII DECEMBER 19, 1917 No. 21

OCEANOGRAPHY.—*An instrument for accurate and rapid density measurements on board ship.*[1] A. L. THURAS, Bureau of Standards. (Communicated by S. W. Stratton.)

The ordinary hydrometer has long been discarded for accurate oceanographic work because of the irregularities and variations in its indications. Almost all of these errors are to be found at the surface of the liquid measured, as for instance, changes in surface tension, impurities on the surface influencing the shape of the meniscus on the stem of the hydrometer, and irregularities in the wetting of the stem. These errors are all eliminated in the float, or bobbin, of total immersion. Therefore this method has been investigated and studied with the hope of possibly improving and simplifying it, so that rapid and accurate density measurements can be made on board ship.

The method was probably first suggested by Pisati and described in 1890 by Reggianni, who used hydrometers of total immersion on board the *Washington* of the Royal Italian Navy in the Mediterranean in 1883. He used two modifications, one consisting of a hydrometer of constant specific gravity and the other consisting of a hydrometer of variable specific gravity. In the first modification, equilibrium in weight of the hydrometer and solution was effected by adding measured quantities of distilled water to the solution; in the second modification equilibrium was

[1] Done under the auspices of the Interdepartmental Committee on Oceanography, subcommittee on instruments, apparatus, and measurements.

attained by adding weights to the hydrometer. Reggianni did not determine the specific gravity of the sea water beyond the fourth place of decimals.

Dr. Nansen in 1896, while studying the salinity of the North Polar Basin, developed a method similar to the second modification of that of Pisati and Reggianni. A hydrometer of total immersion, 3.5 cm. in diameter and 15 cm. long, of normal Jena glass No. 16^{III} was used. The observations were made in a Dewar cylinder, and equilibrium was attained by adding platinum weights to the float, the final adjustments being made by slightly varying the temperature of the sample until the density of the liquid was exactly equal to the density of the float. The temperature of the sample was carefully measured by three thermometers, the bulbs of which were placed in the upper, middle, and lower strata of the sample. An accuracy of one in the fifth decimal place was attained. Dr. Nansen makes the following remarks in regard to this method:

> It is most astonishing that so little attention has hitherto been paid by oceanographers to this valuable method. . . . . After a little practice I think that the method of those observations might be so arranged that they should not take much more time than ordinary determinations with the hydrometer, if the latter were to be made fairly accurate. In my opinion, the method promises to become important for future oceanographic work, as it should enable us to determine the density and salinity of the ocean with a considerably higher degree of accuracy than has hitherto been reached. And it excludes, even in the case of less skillful investigators, the chief source of error, vitiating, under ordinary circumstances, all observations made with the common hydrometer.

T. W. Richards has also made a careful study of this method and has obtained a much higher degree of accuracy. The solution to be investigated is placed in a liter Erlenmeyer flask immersed in an adequately stirred bath in which the temperature can be kept constant to 0°.001 C. He was able to measure densities to a few units in the seventh decimal place.

A. B. Lamb and R. E. Lee have also attained very high accuracies by using an electromagnetic attraction to obtain the equilibrium condition. A piece of soft iron is enclosed in the bulb of the sinker and by means of an electric current sent

through a properly placed external circuit, an electromagnetic attraction is exerted in a vertical direction on the bulb. The utmost precautions had to be taken to maintain a constant accurately known temperature, to avoid any jarring of the apparatus, and to avoid errors due to eddy currents in the liquid.

In all of these modifications of the total immersion method of measuring the density of liquids, the outstanding difficulty is the production of small and accurately known variations in the bouyancy of the sinker. Some easily variable, easily measurable force that will produce vertical displacements of the bobbin is wanted.

Such a force can most conveniently and easily be obtained indirectly by varying the temperature of the liquid. This method is employed in the apparatus that is described below. Numerous analyses having shown that the composition of sea-water salts is very nearly the same in all parts of the ocean and at all depths, the concentration alone changing, the temperature coefficient of expansion of all samples will be the same and the constant of the apparatus will need be determined but once for all.

The maximum variation in the density of the sea water in the open ocean is less than one per cent, so that the density of the most saline water can be made equal to the density of the least saline water by raising its temperature 20°C. Also, the coefficient of expansion of sea water is so low that a sufficient degree of accuracy in the density can be obtained without an excessively close reading of the temperatures. This method also eliminates measurements other than that of temperature, which is always needed in accurate density determinations.

The apparatus (fig. 1) consists essentially of a test tube containing the float, or bobbin, and the liquid to be measured, a stirred variable temperature bath, and an accurately calibrated thermometer.

The bobbins are made of Jena glass No. 16^{III} about 5 cm. long and 12 mm. in diameter. They were carefully annealed about eight months ago and have probably settled down to a definite volume. The glass test tube to contain the liquid to be meas-

ured is 18 mm. in diameter and 15 cm. long, and requires from 15 to 30 cc. of the liquid to be tested.

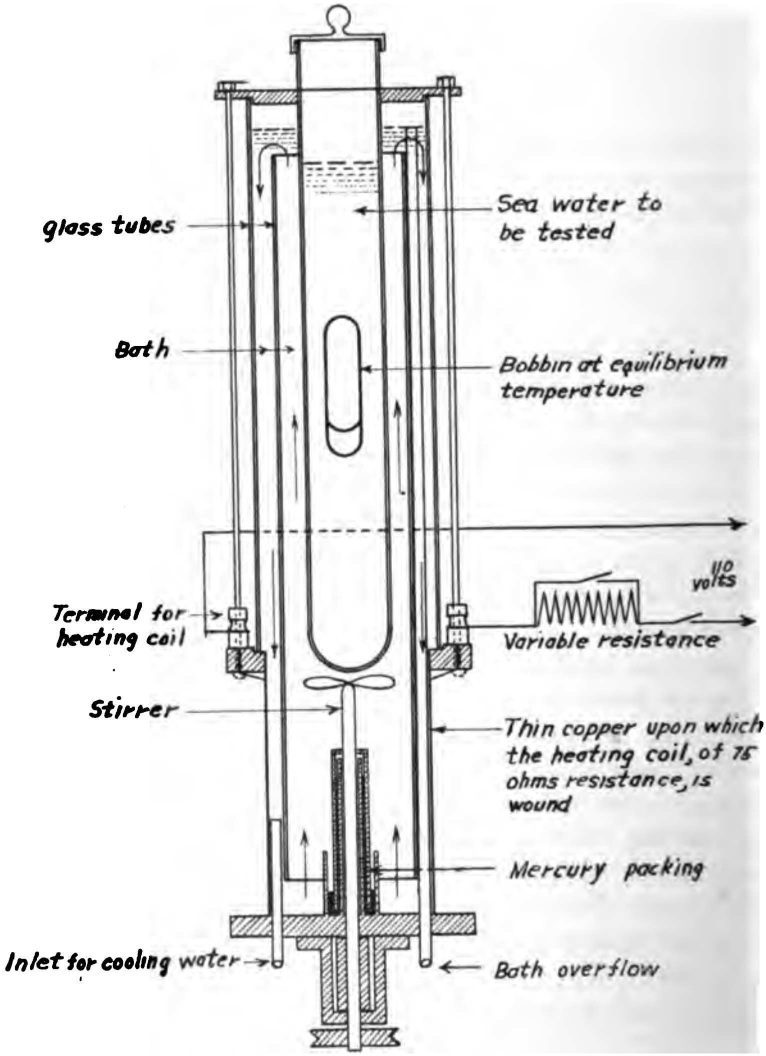

Fig. 1. Apparatus for density determinations.

The temperature bath is of copper and glass and is made as small as possible; it holds only 270 cc. of water. The lower part of the bath is made of 0.3 mm. copper, on the outside of

which is wound 75 ohms of "advance" resistance ribbon, whereby the bath can be rapidly heated electrically. The base contains a stirrer and inlet and outlet tubes for cooling water. The upper part of the bath is made of ordinary glass tubing and contains a copper cover through which a thermometer and the test tube containing the liquid can be inserted.

A standard stem type thermometer graduated in 0°.1 is secured in the cover of the bath with its bulb immersed in the liquid of the bath. The temperatures can easily be read to 0.1 of a division.

The method of making a determination depends on noting the precise temperature at which the liquid to be tested is exactly of the same density as the bobbin. It is apparent that this point, where the bobbin neither sinks nor rises, must occur in a particular liquid at a perfectly definite temperature. In an actual test this equilibrium temperature is not obtained, but pairs of readings approaching it from a higher and from a lower temperature are successively made until a pair is obtained covering such a small range of temperature that their mean may be regarded as sufficiently close to the equilibrium temperature to give the required accuracy in density. The temperature coefficient of sea water is such that a sufficient degree of accuracy can be obtained by determining this equilibrium temperature to 0°.05 C. The rapidity in reaching these points depends on the viscosity of the water and, consequently, increases with the temperature. This in some measure compensates for the decreased sensitivity caused by the increased temperature coefficient at higher temperatures. Therefore a high degree of accuracy in a limited time is not necessarily obtained by cooling the sea water to such a temperature that the coefficient of expansion is small. Consequently that part of the temperature-density curve of sea water which is most convenient to work with has been selected in the present work, and the bobbins have been made of such a density that all of the equilibrium temperatures come between room temperature and about 40°C.

In building this density apparatus the requirements for use at sea have been constantly kept in mind. The essential

requirements are simplicity and convenience of operation, freedom from disturbances due to the motion of the ship, rapidity, accuracy, and limitation in the quantity of test water used.

The apparatus is simple and rugged. All of the glass parts except the thermometer and bobbin are stock articles, and the bath is so constructed that it can easily be replaced if broken. The heating and cooling elements and the stirrer are contained in the copper base and are protected so that they can not easily be injured. The operation of the bath is simple and convenient. The test tube containing the liquid and bobbin is placed in the bath and, by means of the heating coil and cooling tubes the temperature is varied until the equilibrium point is reached. The only readings necessary are the temperatures of the bath for the final two movements of the bobbin.

An instrument that is to be used on board ship should operate rapidly. The bath and test tube containing the sample were therefore made as small as possible, the heating coil was placed close to the liquid of the bath and the cooling water was passed directly into the liquid. With full voltage on the heating coil the bath can be heated 10° in less than two minutes, and can be regulated by an external resistance to 0°.01. The test tube containing the sample is 18 mm. in diameter and has such a small temperature lag that under ordinary circumstances a single test can be made in less than ten minutes.

The accuracy in density determinations demanded in oceanographic work is 1 or 2 units in the fifth decimal place; this requires that the equilibrium temperature be read to 0°.05 C. In figure 2 are shown for each of four bobbins the curve connecting the equilibrium temperature and the salinity and density of the sea water in which it is immersed. Repeated tests on the same sample over several days gave consistent results, and no two tests of the equilibrium temperature had as large a difference as 0°.05.

From some subsurface samples only a limited quantity of the water can be used, as most of the sample is required for biological purposes. With this apparatus 30 cc. is sufficient for a test, and with a little more difficulty a test can be made with only 15 cc.

The only constant error is that due to a permanent change in the volume of the bobbin. To reduce this error the bobbins were constructed with great care. They are made of normal Jena glass No. 16[III] and were carefully annealed about eight months ago. There has not been sufficient time to determine their change in volume due to aging, but it is believed that they have now attained a volume that is constant enough not to affect appreciably the measurements of density. T. W. Richards has

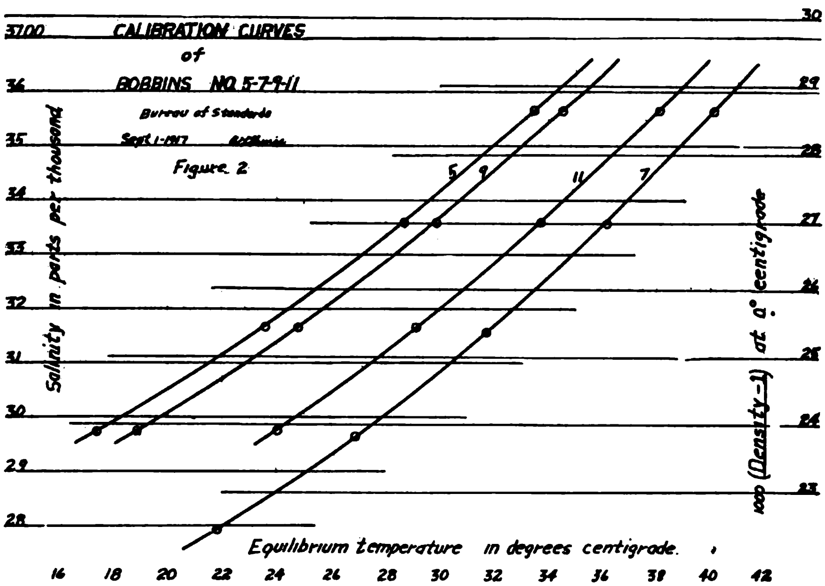

Fig. 2. Relation between equilibrium temperature and density and salinity.

examined carefully the effect of aging, using various kinds of glass, and finds that after three or four months the change in volume of the glass is exceedingly small.

To determine the error due to sudden heating and cooling, the bobbin and liquid were placed in a sealed glass tube and the following results were obtained, using a Beckman thermometer to measure temperatures:

	Equil. temp.
From room temperature	20.74
After being in a bath of 56°C. for 10 minutes	20.75
After being in an ice bath for 10 minutes	20.755
After being in a bath of 80° for 20 minutes	20.75

The changes in density corresponding to these changes in temperature are negligible.

To determine the rapidity and reliability of the method, a series of tests were made on the same sample of water, no single test taking longer than ten minutes. The following results were obtained using a new sample in the test tube for each measurement:

Sample No.	*Equil. temp.*
1	28.40
2	28.38
3	28.39
4	28.38
5	28.40
6	28.39
Mean	28.39

This maximum variation of 0°.01 C. corresponds to less than three in the sixth decimal place of density.

The formation of bubbles on the bobbin is troublesome when a high degree of accuracy is required. It is fortunate, however, that when bubbles are forming on the bobbin it is impossible to obtain an equilibrium temperature. This difficulty may be overcome either by lifting the bobbin out of the liquid just before a reading is taken, or by driving off the air in the liquid by heating the sample to 50° or 60° before making a measurement. The latter method was found the more satisfactory. It eliminated the difficulty completely, but, of course, care must be taken to avoid evaporation.

Conclusion. A simple apparatus is described by which the density of sea water can be measured on board ship with speed and precision. With carefully calibrated bobbins a density measurement of a liquid of known temperature coefficient can be made in less than ten minutes to an accuracy of more than two in the fifth decimal place. The particular advantage of the method lies in the facts that (1) by changing the temperature of the liquid its density can easily and quickly be brought exactly to the density of the bobbin, and (2) at equilibrium temperature the sensitivity of the method is unaffected by the motion of the vessel, the liquid and bobbin having the same density.

INDEX TO VOLUME VII

An * denotes an abstract of a published paper. A † denotes an abstract of a paper presented before the Academy or an affiliated Society.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Anthropological Society of Washington. Proceedings: 47, 139, 169, 202, 273, 360, 395, 544.
Biological Society of Washington. Proceedings: 24, 45, 118, 165, 201, 239, 271, 315, 358, 394.
Botanical Society of Washington. Proceedings: 44, 83, 115, 167, 199, 313, 434, 591.
Chemical Society of Washington. Proceedings: 112, 138.
Geological Society of Washington. Proceedings: 193, 309, 429.
Philosophical Society of Washington. Proceedings: 17, 79, 112, 163, 189, 236, 269, 473, 543, 592.
Society of American Foresters. Proceedings: 139.

AUTHOR INDEX

Adams, L. H. †The effect of positive and of negative pressures on the resistance of metals. 20.
Ashley, G. H. *Notes on the greensand deposits of the eastern United States. 513.
——*Oil resources of black shales of the eastern United States. 564.
Austin, L. W. Notes on the audion. 487.
Avers, H. G. *Precise leveling from Reno to Las Vegas, Nevada, and from Tonopah Junction, Nevada, to Laws, California. 132.
Babcock, M. H. †Certain pre-Columbian notices of the inhabitants of the Atlantic islands. 139.
Bagley, J. W. *The use of the panoramic camera in topographic surveying, with notes on the application of photogrammetry to aerial surveys. 568.
Barber, H. S. †An outline of the glow-worms of the American family Phongodidae. 27.
Barnett, V. H. *Geology of the Hound Creek district of the Great Falls coal field, Montana. 133.
Bartsch, Paul. †Changes in the avifauna about Burlington, Iowa, 1885 to 1917. 166.
——†Mollusk collecting in the Philippines. 25.
Bassler, R. S. †The value of microscopic fossils in stratigraphy. 434.
Bastin, E. S. *Economic geology of Gilpin County and adjacent parts of Clear Creek and Boulder Counties, Colorado. 266.
——*The Gold Log mine, Talladega County, Alabama. 76.
Bateman, H. †The nature of chemical forces. 189.
Bates, C. G. †Relation of plant succession to forestry and grazing. 199.
Bates, Frederick. †The rotation of the plane of polarization in quartz and iron at high temperatures. 473.

BAUER, C. M. *Contributions to the geology and paleontology of San Juan County, New Mexico. I. Stratigraphy of a part of the Chaco River Valley. 133.
BEATTIE, R. K. †The introduction of foreign plant diseases. 168.
BECKER, G. F. *Mechanics of the Panama Canal slides. 13.
BERRY, E. W. *Geologic history indicated by the fossiliferous deposits of the Wilcox group (Eocene) at Meridian, Mississippi. 601.
BICHOWSKY, F. R., VON. The electrometric titration of zinc with ferrocyanide. 141.
——†Valence and color. 192.
BINGHAM, E. C. Standard substances for the calibration of viscometers. 53.
BOWIE, WILLIAM. *Investigations of gravity and isostasy. 159.
——†Our present knowledge of isostasy. 269.
——†Some evidences of isostasy. 311.
BRIGGS, L. J. The living plant as a physical system. 89.
BROOKS, A. H. †Memorial to C. Willard Hayes. 432.
BROWN, G. V. *American occurrence of miloschite. 393.
BUCKINGHAM, E. †The effect of elastic strain on the equilibrium temperature of a solid and its liquid. 79.
BUREAU STANDARDS CIRCULAR No. 66. *Standard samples for thermometric fixed points. 561.
BURGESS, G. K. †The application of science to warfare in France. 592.
——*Temperature measurements in Bessemer and open hearth practice. 464.
——†The resistivity and thermoelectric properties of pure iron. 19.
BURROWS, C. W. *An experimental study of the Fahy permeameter. 562.
BUSHNELL, D. I., JR. The Chitimacha of Bayou La Fourche, Louisiana. 301.
BUTLER, B. S. Magnesioludwigite, a new mineral. 29.
——Tungstenite, a new mineral. 596.
CALKINS, F. C. *Molybdenite and nickel ore in San Diego County, California. 78.
CALVERT, W. R. *Geology of the Upper Stillwater Basin, Stillwater and Carbon Counties, Montana. 135.
CAPPS, S. R. *Mineral resources of the Kantishna region, Alaska. 603.
CASANOWICZ, I. M. †The fish in cult, myth, and symbol. 171.
CASTLE, W. E. The rôle of selection in evolution. 369.
CHASE, AGNES. *Grasses of the West Indies. 516.
CHRISTENSEN, CARL. *Maxonia, a new genus of tropical American ferns. 162.
CLARK, A. H. A revision of the crinoid family Antedonidae, with the diagnosis of nine new genera. 127.
——A revision of the recent genera of the crinoid family Bourgueticrinidae, with the description of a new genus. 388.
——The interrelationships of the subfamilies and genera included in the crinoid family Antedonidae. 504.
CLARKE, F. W. †The development of scientific societies in Washington. 475.
——*The inorganic constituents of marine invertebrates. 562.
CLINE, A. W. †Photoelectric radiophonic experiments. 163.
COBLENTZ, W. W. †Characteristics and comparative sensitiveness of various types of radiometers. 164.
——*Glasses for protecting the eyes from injurious radiations. 268.

——*The emissivity of straight and helical filaments of tungsten. 426.
——*The luminous radiation from a black body, and the mechanical equivalent of light. 542.
——The photoelectric sensitivity of various substances. 525.
——*The reflecting power of tungsten and stellite. 561.
——†The relative sensibility of the average eye to lights of different colors. 17.
——*The relative sensibility of the average eye to light of different colors, and some practical applications to radiation problems. 427.
Cole, F. C. †The pagan tribes of the Philippines. 273.
Colley, R. H. †Technique for the study of the white pine blister rust. 314.
Collier, A. J. †Age of the high gravels of the Northern Great Plains. 194.
Collins, G. N. †Behavior of maize hybrids. 83.
Condit, D. D. *Gypsum in the southern part of the Bighorn Mountains, Wyoming. 78.
——*Relations of the Embar and Chugwater formations in central Wyoming. 162.
Cook, F. C. *Experiments during 1915 in the destruction of fly larvae in horse manure. 161.
——*Experiments in the destruction of fly larvae in horse manure. 161.
Cook, O. F. †Behavior of cotton hybrids. 84.
——Seedling morphology in palms and grasses. 420.
——The Mascarene cabbage palm as a new genus. 121.
Coville, F. V. †Humus as a factor in plant distribution. 436.
——†The influence of cold in stimulating the growth of plants. 394.
——†The origin and use of upland peat. 117.
Cowie, G. D. *Precise leveling from Reno to Las Vegas, Nevada, and from Tonopah Junction, Nevada, to Laws, California. 132.
Crittenden, E. C. *An average eye for heterochromatic photometry. 264.
Dall, W. H. †The origin and early days of the Philosophical Society of Washington. 475.
Darton, N. H. *A comparison of Paleozoic sections in southern New Mexico. 564.
Daudt, H. W. †Investigations of the Kjeldahl method of determining nitrogen. 112.
Day, A. L. †Cooling of a lava surface. 194.
Dean H. J. *Surface waters of Massachusetts. 136.
Dewey, L. H. †Need for textile plant fibers. 591.
Diller, J. S. †More evidence as to the high temperature of the late eruption at Lassen Peak. 193.
——†Was the new lava from Lassen Peak viscous at the time of its eruption? 82.
Dorsey, N. E. Luminescence measurements. 1.
Dufrenoy, J. A new case of metaphanic variation in grasses and its significance. 535.
Eakin, H. M. †The Quaternary history of central Alaska. 81.
Edwards, J. D. *A specific gravity balance for gases. 160.
——*The effusion method of determining gas density. 428.
——†The rapid determination of gas density. 475.
Elvove, Elias. †The separation and determination of small amounts of antimony. 114.
Emerson, W. B. *Glasses for protecting the eyes from injurious radiations. 268.

——*The luminous radiation from a black body, and the mechanical equivalent of light. 542.
——The photoelectric sensitivity of various substances. 525.
——*The reflecting power of tungsten and stellite. 561.
——*The relative sensibility of the average eye to light of different colors, and some practical applications to radiation problems. 427.
EMLEY, W. E. *Durability of stucco and plaster construction. 16.
EMMONS, W. H. *The enrichment of ore deposits. 513.
FAIRCHILD, C. O. The proper type of absorption glass for an optical pyrometer. 545.
FAIRCHILD, DAVID. †The need of more foreign agricultural exploration. 167.
FATH, A. E. *An anticlinal fold near Billings, Noble County, Oklahoma. 38.
FERGUSON, H. G. *Placer deposits of the Manhattan district, Nevada. 266.
FEWKES, J. W. A prehistoric stone mortar from southern Arizona. 459.
——An initiation at Hano in Hopiland, Arizona. 149.
——†Prehistoric ruins of the Mesa Verde National Park. 169.
FOOTE, P. D. Anode resistance films. 593.
——A visibility equation derived from the Ives and Kingsbury new luminosity equation. 317.
——Probe-wire measurements of anode fall of potential. 482.
——The proper type of absorption glass for an optical pyrometer. 545.
——Criteria for gray radiation. 573.
——The resonance and ionization potentials for electrons in sodium vapor. 517.
FOWLE, F. E. †Spectroscopic field light. 238.
FRACHTENBERG, L. J. †The religious ideas of the Northwest Coast Indians. 275.
GALLOWAY, B. T. †The protection and propagation of plant introductions. 168.
GIDLEY, J. W. †The origin of the mammals. 196.
GILBERT, G. K. *Hydraulic-mining débris in the Sierra Nevada. 600.
GILMORE, C. W. *Brachyceratops, a ceratopsian dinosaur from the Two Medicine formation of Montana, with notes on associated fossil reptiles. 267.
——*Contributions to the geology and paleontology of San Juan County, New Mexico. 2. Vertebrate faunas of the Ojo Alamo, Kirtland, and Fruitland formations. 185.
GOLDMAN, M. I. †Results of the microscopic examination of some rocks from the oil fields of southeastern Ohio. 310.
GREGORY, H. E. *The Navajo country, a geographic and hydrographic reconnaisance of parts of Arizona, New Mexico, and Utah. 132.
GROVER, N. C. *Accuracy of streamflow data. 137.
——*Surface water supply of the United States, 1914, Parts I, II, VII, XII. 135.
——et al. *Surface water supply of the United States, 1913, Part X, the Great Basin. 135.
HARES, C. J. *Anticline in central Wyoming. 265.
——†Gastroliths in the Cloverly formation. 429.
——*The lignite field of northwestern South Dakota. 36.
——†The southern extension of the Eagle sandstone and its relation to the Niobrara shale in Wyoming. 429.

HARLAN, H. V. †Behavior of barley hybrids. 85.
HARPER, FRANCIS. †Note on hibernation of the mud-turtle. 315.
HAY, O. P. †On the finding of supposed Pleistocene human remains at Vero, Florida. 358.
HAY, W. P. †Discovery of an interesting new tardigrade. 45.
——†The rate of growth in certain lower vertebrates. 394.
HEALD, K. C. *The oil and gas geology of the Foraker quadrangle, Osage County, Oklahoma. 77.
HERSCHEL, W. H. *The resistance of an oil to emulsification. 137.
HERSEY, M. D. Note on the vibration frequencies of elastic systems. 437.
HESS, F. L. *Tungsten minerals and deposits. 604.
HEWETT, D. F. *Some manganese mines in Virginia and Maryland. 134.
——†The origin of bentonite and the geologic range of related materials in Bighorn Basin, Wyoming. 196.
HILL, E. A. †Van't Hoff's principle of optical superposition. The lactonic constitution of the aldose sugars and the melasaccharins and the constants from which their specific rotary powers can be computed. 113.
HILL, J. M. *Economic geology of Gilpin County and adjacent parts of Clear Creek and Boulder counties, Colorado. 266.
HITCHCOCK, A. S. †Botanizing in the Hawaiian Islands. 316.
——*Grasses of the West Indies. 516.
——Taxonomic botany and the Washington botanist. 251.
——†The "District Flora." 434.
HOFFMAN, J. V. †Relation of plant succession to forestry and grazing. 200.
HOLMES, W. H. †Outlines of American aboriginal history. 50.
HOPKINS, O. B. *Structure of the Vicksburg-Jackson area, Mississippi. 235.
HOSTETTER, J. C. †The influence of non-uniform pressure on solubility. 79.
——†The linear force of growing crystals. 195.
——The thermodynamic reversibility of the equilibrium relations between a strained solid and its liquid. 405.
HOUGH, WALTER. †Ancient pit dwellers in New Mexico. 47.
HOWARD, L. O. †Some European experiences with entomologists. 119.
——The carriage of disease by insects. 217.
HOWELL, A. H. †Notes on American flying squirrels. 358.
HOYT, J. C. *Accuracy of streamflow data. 137.
HUNTER, J. F. *A reconnaisance of the Archean complex of the Granite Gorge, Grand Canyon, Arizona. 38.
HUTCHISON, R. H. †A review of recent work on the house-fly. 25.
——*Experiments during 1915 in the destruction of fly larvae in horse manure. 161.
——*Experiments in the destruction of fly larvae in horse manure. 161.
JACKSON, R. F. Standard substances for the calibration of viscometers. 53.
JAGGAR, T. A., JR. Live aa lava at Kilauea. 241.
——On the terms aphrolith and dermolith. 277.
——Thermal gradient of Kilauea Lava Lake. 397.
JENNINGS, H. S. Observed changes in hereditary characters in relation to evolution. 281.

JOHNSON, J. M. †A fourth pentacetate of galactose. 112.
JONES, E. L., JR. *Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho. 14.
——*Reconnaisance of the Conconully and Ruby mining districts, Washington. 37.
JUDD, N. M. †New types of Pueblo ruins found in western Utah. 49.
KATZ, F. J. †Age of the Worcester phyllite. 309.
——†Stratigraphy in southwest Maine and southeast New Hampshire. 198.
——*The Newington moraine, Maine, New Hampshire, and Massachusetts. 515.
KEITH, ARTHUR. *The Newington moraine, Maine, New Hampshire, and Massachusetts. 515.
KEMPTON, J. H. A correlation between endosperm color and albinism in maize. 146.
KNOPF, ADOLPH. An andalusite mass in the pre-Cambrian of the Inyo Range, California. 549.
——*Tin ore in northern Lander County, Nevada. 15.
——*Tungsten deposits of northwestern Inyo County, California, 357.
KNOWLTON, F. H. *A fossil flora from the Frontier formation of southwestern Wyoming. 601.
——*Contributions to the geology and paleontology of San Juan County, New Mexico. 4. Flora of the Fruitland and Kirtland formations. 186.
LAKE, G. C. †Some observations on the toxicity and chemotherapy of the heavy metals. 114.
LANGMUIR, IRVING. †The constitution of liquids. 474.
LARSEN, E. S. Halloysite from Colorado. 178.
——Leverrierite from Colorado. 208.
——Mineralogic notes. 6.
——The indices of refraction of analyzed rhodochrosite and siderite. 365.
LA RUE, E. C. *Colorado River and its utilization. 15.
LEDOUX, A. Aurichalcite from Big Cottonwood Canyon, Salt Lake County, Utah. 361.
LEE, W. T. †Relations of the Morrison and Sundance formations. 431.
LEIGHTY, C. E. †Behavior of wheat hybrids. 85.
LEWTON, F. L. †R. M. Meade, an appreciation. 115.
LLOYD, E. R. *The lignite field of northwestern South Dakota. 36.
LOEB, L. B. †The electron theory of valence. 191.
LUPTON, C. T. *Gypsum in the southern part of the Bighorn Mountains, Wyoming. 78.
——*The Bull Mountain coal field, Musselshell and Yellowstone counties, Montana. 602.
LYON, M. W., JR. †Poisonous snakes. 46.
——†Precipitins. 240.
MCATEE, W. L. †Showers of organic matter. 166.
MARVIN, C. F. †Aerology in aid of aeronautics. 543.
MEGGERS, W. F. †Interference measurements of wave-lengths, and infra-red spectrum photography. 237.
——*Wave-length measurements in spectra from 5900 Å to 9600 Å. 585.
MERICA, P. D. *The structure of the coating on tinned sheet copper in relation to a curious case of corrosion of this material. 161.
MERRILL, P. W. *Wave-lengths of the stronger lines in the helium spectrum. 393.

MERWIN, H. E. †Diffusion and crystallization of metallic copper in crystalline sulphides. 196.
——Dispersion and other optical properties of carborundum. 445.
METCALF, HAVEN. †Control of the white-pine blister rust. 313.
MICHELSON, TRUMAN. †Notes on the Peoria Indians. 51.
——Remarks on American Indian languages, a study in method. 222.
——Remarks on terms of relationship. 181.
MILLIKAN, R. A. †The organization of scientific effort in relation to the war. 592.
MILLS, R. V. A. †Evaporation of water at depth by natural gases. 309.
MISER, H. D. *Manganese deposits of the Caddo Gap and De Queen quadrangles, Arkansas. 587.
MOHLER, F. L. The proper type of absorption glass for an optical pyrometer. 545.
MOREY, G. W. A convenient form of autoclave. 205.
MORSE, W. J. †Behavior of soy bean hybrids. 87.
MYERS, C. N. †The preparation of heavy-metal salts of certain organic acids. 114.
NORTON, J. B. †Behavior of crosses between wheat and rye. 85.
NOBLE, L. F. *A reconnaisance of the Archean complex of the Granite Gorge, Grand Canyon, Arizona. 38.
OBERHOLSER, H. C. *Critical notes on the eastern subspecies of *Sitta carolinensis* Latham. 590.
——*Description of a new genus of Anatidae. 589.
——*Description of a new Sialia from Mexico. 589.
——Diagnosis of a new laniine family of Passeriformes. 180.
——Diagnosis of a new pycnonotine family of Passeriformes. 537.
——†Recent additions to the list of North American birds. 120.
——*Notes on the fringilline genus Passerherbulus and its nearest allies. 588.
——*Notes on North American birds. I. 589.
——*A synopsis of the races of *Bombycilla garrula* (Linnaeus). 590.
——*The status of *Aphelocoma cyanotis* and its allies. 588.
ORTON, W. A. †Disease resistance in plant hybrids. 86.
——†Pathological problems in the distribution of perishable plant products. 45.
OSBORNE, N. S. †A calorimeter for the determination of latent and specific heats of fluids. 22.
——*An aneroid calorimeter for specific and latent heats. 426.
PAINE, J. H. †Scientific photography in the study of insects. 28.
PALMER, T. S. †A pioneer naturalist in southern Florida.—Extracts from the diary of Titian R. Peale, 1825. 201.
PALMER, WILLIAM. †Porpoises and steamers. 240.
——†The fossil sea cow of Maryland. 120.
PARKS, E. M. *The lignite field of northwestern South Dakota. 36.
PEARSON, J. C. *Durability of stucco and plaster construction. 16.
PETERS, C. G. †An interferential method for measuring the expansion of very small samples. 475.
PFUND, A. H. †The colors of mother-of-pearl. 236.
PHELPS, F. P. †The rotation of the plane of polarization in quartz and iron at high temperatures. 473.
PIERCE, C. H. *Surface waters of Massachusetts. 136.

PIERCE, R. C. *The measurement of silt-laden streams. 136.
PIERCE, W. D. †Extraordinary strepsipterous type of parasitism. 272.
——†Recent spread of the cotton boll weevil. 26.
PITTIER, HENRY. †Forests of Panama. 27.
——*New or noteworthy plants from Colombia and Central America—6. 566.
——*Preliminary revision of the genus Inga. 567.
——*The Middle American species of Lonchocarpus. 567.
POWER, F. B. †Aims and developments of phytochemical research. 138.
PRIEST, I. G. †An interferential method for measuring the expansion of very small samples. 475.
QUAINTANCE, A. L. †Some notes on the Aleyrodidae. 201.
REID, H. F. †The distribution of land and water on the earth. 311.
RICHARDS, R. W. *The Bull Mountain coal field, Musselshell and Yellowstone counties, Montana. 602.
RICHARDSON, G. B. Note on the diffusion of sodium chloride in Appalachian oil-field waters. 73.
RICHTMYER, F. K. *An average eye for heterochromatic photometry. 264.
RICKER, P. L. †Collecting and preparing specimens. 436.
RIDDLE, OSCAR. The control of the sex ratio. 319.
ROBINSON, H. M. *Ozokerite in central Utah. 76.
ROESER, H. M. *The calculation of the constants of Planck's radiation equation; an extension of the theory of least squares. 542.
ROGERS, G. S. *Baked shale and slag formed by the burning of coal beds. 563.
——*Chemical relations of the oil-field waters in San Joaquin Valley, California. 586.
——*The Cleveland gas field, Cuyahoga County, Ohio. 308.
ROSE, J. N. †Exhibition of Venezuelan plants and fruits. 46.
SAFFORD, W. E. †Magic plants of the ancient Americans. 47.
SAMPSON, A. W. †Relation of plant succession to forestry and grazing. 200.
SANFORD, R. L. *An experimental study of the Fahy permeameter. 562.
——*Determination of the degree of uniformity of bars for magnetic standards. 14.
SASSCER, E. R. †Remarks on entomological inspection and disinfection of products offered for entry into the United States. 26.
SCALES, F. M. *Experiments in the destruction of fly larvae in horse manure. 161.
SCHALLER, W. T. Ilsemannite, hydrous sulphate of molybdenum. 417.
——Magnesioludwigite, a new mineral. 29.
——Minasragrite, a hydrous sulphate of vanadium. 501.
SCHULTZ, H. I. *An investigation of the axial aberrations of lenses. 585.
SHAW, E. W. A new area of Carboniferous rocks with some coal in the north end of the Gulf embayment. 552.
——*The Irvine oil field, Estill County, Kentucky. 514.
SHEAR, C. L. †Pathological problems in the distribution of perishable plant products. 45.
SHUFELDT, R. W. †Notes on the trunk-fishes. 201.
——†Zoological statuary at the National Capitol. 273.

SMITH, E. F. *Mechanism of tumor growth in crown gall. 187.
SMITH, G. O. †Geology and public service. 193.
SMITH, H. M. †Exploitation of neglected aquatic resources. 165.
SMITH, W. H. *Recovery of paraffin and paper stock from waste paraffin paper. 39.
SOSMAN, R. B. Some problems of the oxides of iron. 55.
STANDLEY, P. C. *The Mexican and Central American species of Ficus. 566.
STANTON, T. W. †A Cretaceous volcanic ash bed on the Great Plains in North Dakota. 80.
——*Contribution to the geology and paleontology of San Juan County, New Mexico. 3. Nonmarine Cretaceous invertebrates of the San Juan basin. 185.
STEBINGER, EUGENE. *Anticlines in the Blackfeet Indian Reservation, Montana. 264.
——*Possibilities of oil and gas in north-central Montana. 77.
STEIGER, GEORGE. Mineralogic notes. 6.
STEPHENSON, L. W. *North American Upper Cretaceous corals of the genus Micrabacia. 39.
——Tongue, a new stratigraphic term, with illustrations from the Mississippi Cretaceous. 243.
STIMSON, H. F. A two-stage mercury vapor pump. 477.
STOSE, G. W. †Age of certain shales in Cumberland-Lebanon Valley, Pennsylvania. 82.
——†Corals growing along the coast of Delaware. 432.
STRINGHAM, EMERSON. †The shad and its relatives in the Mississippi River. 201.
SUDWORTH, G. B. †Distribution of trees in the District Flora area. 435.
SWANN, W. F. G. †On the absorption of energy by an electron. 19.
——†Origin of the earth's electric charge. 270.
SWANTON, J. R. Significance of the terms for brother and sister among primitive peoples. 31.
——†Some anthropological misconceptions. 395.
——and others. †Problems connected with the distribution of the aboriginal population of America. 202.
SWICK, C. H. *Triangulation in Georgia. 584.
SWINGLE, W. T. †Behavior of Citrus hybrids. 87.
——†The wild relatives of our crop plants; their value in breeding; how to secure them. 167.
TATE, J. T. Anode resistance films. 593.
——Probe-wire measurements of anode fall of potential. 482.
——The resonance and ionization potentials for electrons in sodium vapor. 517.
TAYLOR, A. H. †A normal eye for the photometry of lights of different color. 17.
TAYLOR, H. F. †A mortality of fishes on the west coast of Florida. 166.
TAYLOR, W. P. †Notes on Aplodontia. 272.
THOM, CHARLES. †Some natural groups in Aspergillus. 315.
THOMPSON, H. C. †Experiments in the use of peat in the greenhouse. 116.
THURAS, A. L. An instrument for accurate and rapid density measurements on board ship. 605.
TILLYER, E. D. *An investigation of the axial aberrations of lenses. 585.
TRUE, R. H. †Notes on the life of John Bradbury. 44.

UMPLEBY, J. B. *Geology and ore deposits of the Mackay region, Idaho. 514.
VAUGHAN, T. W. †Significance of reef coral fauna at Carrizo Creek, Imperial County, California. 83, 194.
VINAL, G. W. *Some electrical properties of silver sulphide. 584.
WALCOTT, C. D. *Fauna of the Mount Whyte formation. 565.
WALKER, T. L. The crystal form of spencerite. 456.
WEIBEL, ERNEST. *A study of electromagnet moving coil galvanometers for use in alternating current measurements. 36.
WELLS, P. V. †A standard of turbidity. 473.
WELLS, R. C. †Evaporation of water at depth by natural gases. 309.
——Tungstenite, a new mineral. 596.
WENNER, F. †The experimental basis for Ohm's law. 21.
WETMORE, ALEXANDER. †Note on hibernation of the mud-turtle. 315.
——*The birds of Culebra Island, Porto Rico. 588.
WHEELER, W. C. *The inorganic constituents of marine invertebrates. 562.
WHERRY, E. T. *American occurrence of miloschite. 393.
——Clay derived from volcanic dust in the Pierre in South Dakota. 576.
——*Glauberite crystal cavities in the Triassic rocks of eastern Pennsylvania. 268.
——†Geological areas about Washington. 435.
——Halloysite from Colorado. 178.
——Leverrierite from Colorado. 208.
——Neodymium as the cause of the red-violet color in certain minerals. 143.
——*Notes on alunite, psilomelanite, and titanite. 267.
——†Occurrence of calcite in silicified wood. 433.
——The indices of refraction of analyzed rhodochrosite and siderite. 365.
——The nomenclature and classification of the native element minerals. 447.
——*Two new fossil plants from the Triassic of Pennsylvania. 393.
WHITE, DAVID. †Discussion of gravity anomalies from the stratigraphic standpoint. 312.
——†Dr. C. A. Davis, an appreciation. 115.
WHITE, W. P. †Specific heats at high temperatures. 21.
WIG, R. J. *Durability of stucco and plaster construction. 16.
WILHELM, R. M. *The freezing point of mercury. 13.
WILLIAMSON, E. D. †The effect of elastic strain on the equilibrium temperature of a solid and its liquid. 79.
WILSON, E. B. Note on multiple algebra: The reduction of real dyadics and the classification of real homogeneous strains. 173.
WINCHESTER, D. E. †Oil shale in the United States. 432.
——*The lignite field of northwestern South Dakota. 36.
——*Oil shale in northwestern Colorado and adjacent areas. 265.
WOOLSEY, L. H. *The Bull Mountain coal field, Musselshell and Yellowstone counties, Montana. 602.
WOOTON, E. O. †Relation of plant succession to forestry and grazing. 200.
WRIGHT, F. E. †The application of polarized light to the study of opaque substances. 473.
——The thermodynamic reversibility of the equilibrium relations between a strained solid and its liquid. 405.
WRIGHT, SEWELL. The average correlation within subgroups of a population. 532.

SUBJECT INDEX

Agriculture. †Foreign agricultural exploration. DAVID FAIRCHILD. 167.
†Plant introductions, protection and propagation of. B. T. GALLOWAY. 168.
†Crop plants, wild relatives of; their value in breeding; how to secure them. W. T. SWINGLE. 167.
Anthropology. †Aboriginal population of America, distribution of. J. R. SWANTON, ALES HRDLIČKA, TRUMAN MICHELSON, W. H. HOLMES, J. W. FEWKES, WALTER HOUGH, FRANCIS LA FLESCHE. 202.
Aboriginal terms for brother and sister. J. R. SWANTON. 31.
†American aboriginal history, outlines of. W. H. HOLMES. 50.
†Anthropological misconceptions. J. R. SWANTON. 395.
†The fish in cult, myth, and symbol. I. M. CASANOWICZ. 171.
†Magic plants of the ancient Americans. W. E. SAFFORD. 47.
†Peoria Indians, nötes on. TRUMAN MICHELSON. 51.
Terms of relationship. TRUMAN MICHELSON. 181.
See also: Archeology; Ethnology.
Archeology. †Ancient pit dwellers in New Mexico. WALTER HOUGH. 47.
†Mesa Verde National Park, prehistoric ruins of. J. W. FEWKES. 169.
†Pueblo ruins in western Utah, new types of. N. M. JUDD. 49.
Astrophysics. References. 465.
Biology. Organic matter, showers of. W. L. MCATEE. 166.
Biophysics. The living plant as a physical system. L. J. BRIGGS. 89.
Botany. †Aspergillus, natural groups in. CHARLES THOM. 315.
†Barley hybrids, behavior of. H. V. HARLAN. 85.
†Bradbury, John, life of. R. H. TRUE. 44.
†Citrus hybrids, behavior of. W. T. SWINGLE. 87.
†Collecting and preparing specimens. P. L. RICKER. 436.
*Colombia and Central America, new or noteworthy plants from. HENRY PITTIER. 566.
†Cotton hybrids, behavior of. O. F. COOK. 84.
†Davis, Dr. C. A.; an appreciation. DAVID WHITE. 115.
†District Flora area, distribution of trees in. G. B. SUDWORTH. 435.
†"District Flora." A. S. HITCHCOCK. 434.
*Ficus, Mexican and Central American species of. P. C. STANDLEY. 566.
†Forests of Panama. HENRY PITTIER. 27.
*Grasses of the West Indies. A. S. HITCHCOCK and AGNES CHASE. 516.
†Greenhouse use of peat. H. C. THOMPSON. 116.
†Hawaiian Islands, botanizing in. A. S. HITCHCOCK. 316.
†Humus as a factor in plant distribution. F. V. COVILLE. 436.
*Inga, revision of. HENRY PITTIER. 567.
Local flora, study of. A. S. HITCHCOCK. 251.
*Lonchocarpus, Middle American species of. HENRY PITTIER. 567.
†Maize hybrids, behavior of. G. N. COLLINS. 83.
Mascarene cabbage palm, a new genus. O. F. COOK. 121.

*Maxonia, a new genus of tropical American ferns. CARL CHRISTENSEN. 162.
†Meade, R. M.; an appreciation. F. L. LEWTON. 115.
†Pathological problems in distribution of perishable plant products. C. L. SHEAR and W. A. ORTON. 45.
†Peat, upland, its origin and use. F. V. COVILLE. 117.
†Plant hybrids, disease resistance of. W. A. ORTON. 86.
Seedling morphology in palms and grasses. O. F. COOK. 420.
†Soy bean hybrids, behavior of. W. J. MORSE. 87.
†Textile plant fibers, need for. L. H. DEWEY. 591.
†Venezuelan plants and fruits. J. N. ROSE. 46.
†Wheat and rye, crosses between. J. B. NORTON. 85.
†Wheat hybrids, behavior of. C. E. LEIGHTY. 85.
References. 490.
See also: Agriculture; Biophysics; Ecology; Forestry; Genetics; Paleontology; Phytopathology; Plant Physiology.

Chemistry. †Antimony, separation and determination of. ELIAS ELVOVE. 114.
†Chemical forces, nature of. H. BATEMAN. 189.
†Galactose, a fourth pentacetate of. J. M. JOHNSON. 112.
Iron oxides, some problems of. R. B. SOSMAN. 55.
†Kjeldahl method of determining nitrogen. H. W. DAUDT. 112.
†Phytochemical research, its aims and developments. F. B. POWER. 138.
†Precipitins. M. W. LYON, JR. 240.
†Preparation of heavy-metal salts of certain organic acids. C. N. MYERS. 114.
†Toxicity and chemotherapy of the heavy metals. G. C. LAKE. 114.
†Valence, electron theory of. L. B. LOEB. 191.
†Valence and color. F. R. v. BICHOWSKY. 192.
†Van't Hoff's principle of optical superposition. E. A. HILL. 113.
References. 40, 469.
See also: Crystallography; Electrochemistry; Geology; Geophysics; Mineralogy; Physical Chemistry; Technology.

Crystallography. The thermodynamic reversibility of the equilibrium relations between a strained solid and its liquid. F. E. WRIGHT and J. C. HOSTETTER. 405.

Ecology. †Plant succession and forestry and grazing, relation of. C. G. BATES, J. V. HOFFMAN, A. W. SAMPSON, and E. O. WOOTON. 199, 200.

Economics. †Neglected aquatic resources. H. M. SMITH. 165.
†Geology and public service. G. O. SMITH. 193.

Electricity. Anode fall of potential, probe-wire measurements of. J. T. TATE and P. D. FOOTE. 482.
Anode resistance films. J. T. TATE and P. D. FOOTE. 593.
†Electron, absorption of energy by. W. F. G. SWANN. 19.
Electrons in sodium vapor, resonance and ionization potentials. J. T. TATE and P. D. FOOTE. 517.
*Galvanometer for use in alternating current measurements. ERNEST WEIBEL. 36.
†Iron, pure, resistivity and thermoelectric properties of. G. K. BURGESS. 19.
†Ohm's law, experimental basis for. F. WENNER. 21.
†Photoelectric radiophonic experiments. A. W. CLIME. 163.

Photoelectric sensitivity of various substances. W. W. Coblentz and W. B. Emerson. 525.
†Resistance of metals, effect of positive and of negative pressure. L. H. Adams. 20.
*Silver sulphide, some electrical properties of. G. W. Vinal. 584.
Electrochemistry. The electrometric titration of zinc with ferrocyanide. F. R. v. Bichowsky. 141.
Engineering. *Colorado River and its utilization. E. C. La Rue. 15.
*Measurement of silt-laden streams. R. C. Pierce. 136.
*Panoramic camera, its use in topographic surveying. J. W. Bagley. 568.
*Stream-flow data, accuracy of. N. C. Grover and J. C. Hoyt. 137.
*Surface waters of Massachusetts. C. H. Pierce. 136.
*Surface water supply of the United States. N. C. Grover, et al. 135.
See also: Geology.
Entomology. †Aleyrodidae, notes on. A. L. Quaintance. 201.
†Boll weevil, recent spread of. W. D. Pierce. 26.
†Entomological inspection of imports. E. R. Sasscer. 26.
†European entomologists. 119.
*Fly larvae in horse manure, destruction of. F. C. Cook, R. H. Hutchison, and F. M. Scales. 161.
†Glow-worms of family Phongodidae. H. S. Barber. 27.
†House-fly, recent work on. R. H. Hutchison. 25.
†Insect photography. J. H. Paine. 28.
†Strepsipterous type of parasitism. W. D. Pierce. 272.
Ethnology. American Indian languages. Truman Michelson. 222.
The Chitimacha of Bayou La Fourche, Louisiana. D. I. Bushnell, Jr. 301.
Initiation in Hopiland, Arizona. J. W. Fewkes. 149.
†Pagan tribes of the Philippines. F. C. Cole. 273.
†Pre-Columbian notices of inhabitants of the Atlantic islands. W. H. Babcock. 139.
Prehistoric stone mortar from Arizona. J. W. Fewkes. 459.
†Religious ideas of the Northwest Coast Indians. L. J. Frachtenberg. 275.
Forestry. References. 492.
Genetics. Endosperm color and albinism in maize, correlation between. J. H. Kempton. 146.
Hereditary characters in relation to evolution, observed changes in. H. S. Jennings. 281.
Metaphanic variation in grasses. J. Dufrenoy. 535.
Population, average correlation within subgroups of. Sewell Wright. 532.
Selection in evolution, rôle of. W. E. Castle. 369.
Sex ratio, the control of. Oscar Riddle. 319.
References. 497.
Geodesy. Precise leveling from Reno to Las Vegas, Nevada, and from Tonopah Junction, Nevada, to Laws, California. H. G. Avers and G. D. Cowie. 132.
*Triangulation in Georgia. C. H. Swick. 584.
References. 466.
See also: Gravitation.
Geography. *Navajo country, a geographic and hydrographic reconnaisance. H. E. Gregory. 132.
Geology. †Age of certain shales in Cumberland-Lebanon Valley, Pennsylvania. G. W. Stose. 82.
†Age of the Worcester phyllite. F. J. Katz. 309.
Andalusite mass in the pre-Cambrian of the Inyo Range, California. Adolph Knopf. 549.

*Anticlinal fold near Billings, Oklahoma. A. E. FATH. 38.
*Anticlines in the Blackfeet Indian Reservation. EUGENE STEBINGER. 264.
*Anticlines in central Wyoming. C. J. HARES, 265.
Aphrolith and dermolith. T. A. JAGGAR, JR. 277.
*Archean complex of Granite Gorge, Grand Canyon, Arizona, reconnaisance of. L. F. NOBLE and J. F. HUNTER. 38.
*Baked shale and slag formed by the burning of coal beds. G. S. ROGERS. 563.
†Bentonite, origin of; geologic range of related material. D. F. HEWETT. 196.
*Bull Mountain coal field, Montana. L. H. WOOLSEY, R. W. RICHARDS, and C. T. LUPTON. 602.
Carboniferous rocks with some coal, new area of, in the north end of the Gulf embayment. E. W. SHAW. 552.
Clay derived from volcanic dust in South Dakota. E. T. WHERRY. 576.
*Cleveland gas field, Ohio. G. S. ROGERS. 308.
Conconully and Ruby mining districts, Washington, reconnaisance of. E. L. JONES, JR. 37.
*Cretaceous invertebrates, nonmarine, of the San Juan basin, New Mexico. T. W. STANTON. 185.
†Cretaceous volcanic ash bed on the Great Plains in North Dakota. T. W. STANTON. 80.
†Diffusion and crystallization of metallic copper in crystalline sulphides. H. E. MERWIN. 196.
†Distribution of land and water on the earth. H. F. REID. 311.
†Eagle sandstone, relation of to Niobrara shale in Wyoming. C. J. HARES. 429.
*Economic geology of Gilpin County and adjacent territory, Colorado. J. M. HILL. 266.
*Embar and Chugwater formations in central Wyoming, relations of. D. D. CONDIT. 162.
*Enrichment of ore deposits. W. H. EMMONS. 513.
†Evaporation of water at depth by natural gases. R. V. A. MILLS and R. C. WELLS. 309.
*Flora of the Fruitland and Kirtland formations, New Mexico. F. H. KNOWLTON. 186.
*Fossil flora from the Frontier formation of Wyoming. F. H. KNOWLTON. 601.
*Gold Log mine, Alabama. E. S. BASTIN. 76.
†Gravels, high, of northern Great Plains, age of. A. J. COLLIER. 194.
†Gravity anomalies from the stratigraphic standpoint. DAVID WHITE. 312.
*Greensand deposits of the eastern United States. G. H. ASHLEY. 513.
*Gypsum in Bighorn Mountains, Wyoming. C. T. LUPTON and D. D. CONDIT. 78.
*Hound Creek coal district, Montana, geology of. V. H. BARNETT. 133.
†Human remains at Verò, Florida, finding of supposed Pleistocene. O. P. HAY. 358.
*Hydraulic-mining débris in the Sierra Nevada. G. K. GILBERT. 600.
*Irvine oil field, Kentucky. E. W. SHAW. 514.
†Isostasy, our present knowledge of. WILLIAM BOWIE. 269.
†Isostasy, some evidences of. WILLIAM BOWIE. 311.
†Lassen Peak eruption, high temperature of. J. S. DILLER. 193.

†Lassen Peak lava; was it viscous at time of eruption? J. S. DILLER. 82.
*Lignite field of northwestern South Dakota. D. E. WINCHESTER, C. J. HARES, E. R. LLOYD, and E. M. PARKS. 36.
*Lode mining in Boise Basin, Idaho. E. L. JONES, JR. 14.
*Mackay region, Idaho, geology and ore deposits of. J. B. UMPLEBY. 514.
*Manganese deposits of the Caddo Gap and De Queen quadrangles, Arkansas. H. D. MISER. 587.
*Manganese mines in Virginia and Maryland. D. F. HEWETT. 134.
*Marine invertebrates, inorganic constituents of. F. W. CLARKE and W. C. WHEELER. 562.
*Mechanics of Panama Canal slides. G. F. BECKER. 13.
†Memorial to C. Willard Hayes. A. H. BROOKS. 432.
*Mineral resources of the Kantishna region, Alaska. S. R. CAPPS. 603.
*Molybdenite and nickel ore in San Diego County, California. F. C. CALKINS. 78.
†Morrison and Sundance formations, relations of. W. T. LEE. 431.
*Newington moraine, Maine, New Hampshire, and Massachusetts. F. J. KATZ and ARTHUR KEITH. 515.
*Oil and gas geology of the Foraker quadrangle, Oklahoma. K. C. HEALD. 77.
*Oil and gas in north-central Montana, possibilities of. EUGENE STEBINGER. 77.
Oil-field waters, Appalachian, sodium chloride in. G. B. RICHARDSON. 73.
*Oil-field waters in San Joaquin Valley, California, chemical relations of. G. S. ROGERS. 586.
†Oil-shale in the United States. D. E. WINCHESTER. 432.
*Oil-shale in northwestern Colorado and adjacent areas. D. E. WINCHESTER. 265.
*Oil resources of black shales of the eastern United States. G. H. ASHLEY. 564.
*Ozokerite in central Utah. H. M. ROBINSON. 76.
*Paleozoic sections in southern New Mexico, comparison of. N. H. DARTON. 564.
*Placer deposits of the Manhattan district, Nevada. H. G. FERGUSON. 266.
†Quaternary history of central Alaska. H. M. EAKIN. 81.
†Reef coral fauna at Carrizo Creek, California, significance of. T. W. VAUGHAN. 83, 194.
†Stratigraphy, value of microscopic fossils in. R. S. BASSLER. 434.
†Stratigraphy in southwest Maine and southeast New Hampshire. F. J. KATZ. 198.
Stratigraphy of the Chaco River Valley, New Mexico. C. M. BAUER. 133.
*Tin ore in Lander County, Nevada. ADOLPH KNOPF. 15.
Tongue, a new stratigraphic term. L. W. STEPHENSON. 243.
*Tungsten deposits of northwestern Inyo County, California. ADOLPH KNOPF. 357.
*Tungsten minerals and deposits. F. L. HESS. 604.
*Upper Stillwater Basin, Montana, geology of. W. R. CALVERT. 135.
*Vertebrate faunas of the Ojo Alamo, Kirtland, and Fruitland formations, New Mexico. C. W. GILMORE. 185.
*Vicksburg-Jackson area, Mississippi, structure of. O. B. HOPKINS. 235, 427.

†Washington, D. C., Geological areas. E. T. WHERRY. 435.
*Wilcox group (Eocene), geologic history of. E. W. BERRY. 601.
See also: Economics; Engineering; Geography; Gravitation; Mineralogy; Paleontology; Petrology.

Geophysics. †Cooling of a lava surface. A. L. DAY. 194.
†Crystals, growing, linear force of, J. C. HOSTETTER. 195.
Live aa lava at Kilauea. T. A. JAGGAR, JR. 241.
†Origin of the earth's electric charge. W. F. G. SWANN. 270.
Thermal gradient of Kilauea Lava Lake. T. A. JAGGAR, JR. 397.
References. 465.

Gravitation. *Investigations of gravity and isostasy. WILLIAM BOWIE. 159.
References. 466.

History. Philosophical Society of Washington, origin and early days of. W. H. DALL. 475.
†Scientific societies in Washington, development of. F. W. CLARKE. 475.

Magnetism. *Fahy permeameter. C. W. BURROWS and R. L. SANFORD. 562.
*Uniformity of bars for magnetic standards. R. L. SANFORD. 14.

Mammalogy. †American flying squirrels, notes on. A. H. HOWELL. 358.
†*Aplodontia*, notes on. W. P. TAYLOR. 272.
References. 40.

Mathematics. Multiple algebra: The reduction of real dyadics and the classification of real homogeneous strains. E. B. WILSON. 173.

Medical Zoology. Carriage of disease by insects. L. O. HOWARD. 217.

Metallography. *Coating on tinned copper, corrosion of. P. D. MERICA. 161.
References. 470.

Meteorology. †Aerology in aid of aeronautics. C. F. MARVIN. 543.

Mineralogy. Alunite, psilomelanite, and titanite. E. T. WHERRY. 267.
Aurichalcite from Big Cottonwood Canyon, Utah. A. LEDOUX. 361.
†Calcite in silicified wood. E. T. WHERRY. 433.
*Glauberite crystal cavities in the Triassic rocks of eastern Pennsylvania. E. T. WHERRY. 268.
Halloysite from Colorado. E. S. LARSEN and E. T. WHERRY. 178.
Ilsemannite, hydrous sulphate of molybdenum. W. T. SCHALLER. 417.
Leverrierite from Colorado. E. S. LARSEN and E. T. WHERRY. 208.
Magnesioludwigite, a new mineral. B. S. BUTLER and W. T. SCHALLER. 29.
*Miloschite, American occurrence of. E. T. WHERRY and G. V. BROWN. 393.
Minasragrite, a hydrous sulphate of vanadium. W. T. SCHALLER. 501.
Mineralogic notes. E. S. LARSEN and G. STEIGER. 6.
Neodymium as cause of red-violet color in certain minerals. E. T. WHERRY. 143.
Native element minerals, nomenclature and classification of. E. T. WHERRY. 447.
Rhodochrosite and siderite, indices of refraction of. E. T. WHERRY and E. S. LARSEN. 365.
Spencerite, crystal form of. T. L. WALKER. 456.
Tungstenite, a new mineral. R. C. WELLS and B. S. BUTLER. 596.
See also: Crystallography.

Oceanography. Instrument for density measurements on board ship. A. L. THURAS. 605.

Optics. *Axial aberrations of lenses. E. D. TILLYER and H. I. SCHULTZ. 585.
Dispersion and other optical properties of carborundum. H. E. MERWIN. 445.
†Mother-of-pearl, colors of. A. H. Pfund. 236.
*Reflecting power of tungsten and stellite. W. W. COBLENTZ and W. B. EMERSON. 561.
†Rotation of the plane of polarization in quartz and iron at high temperatures. FREDERICK BATES and F. P. PHELPS. 473.
†Turbidity, a standard of. P. V. WELLS. 473.

Ornithology. †Additions to list of North American birds. H. C. OBERHOLSER. 120.
*Anatidae, a new genus of. H. C. OBERHOLSER. 589.
**Aphelocoma cyanotis* and its allies, status of. H. C. OBERHOLSER. 588.
†Changes in avifauna about Burlington, Iowa. PAUL BARTSCH. 166.
**Bombycilla garrula*, synopsis of races of. H. C. OBERHOLSER. 590.
*Culebra Island, Porto Rico, birds of. ALEXANDER WETMORE. 588.
*Fringilline genus Passerherbulus and its nearest allies. H. C. OBERHOLSER. 588.
New laniine family of Passeriformes. H. C. OBERHOLSER. 180.
*Notes on North American birds. I. H. C. OBERHOLSER. 589.
New pycnonotine family of Passeriformes. H. C. OBERHOLSER. 537.
*Sialia from Mexico, new. H. C. OBERHOLSER. 589.
**Sitta carolinensis*, the eastern subspecies of. H. C. OBERHOLSER. 590.
References. 497, 569.

Paleontology. *Brachyceratops, a ceratopsian dinosaur from the Two Medicine formation of Montana. C. W. GILMORE. 267.
*Fauna of the Mount White formation. C. D. WALCOTT. 565.
†Gastroliths in the Cloverly formation. C. J. HARES. 429.
*North American Upper Cretaceous corals of the genus Micrabacia. L. W. STEPHENSON. 39.
*Plants from the Triassic of Pennsylvania. E. T. WHERRY. 393.
†Seacow of Maryland, fossil. WILLIAM PALMER. 120.
References. 490.

Petrology. †Results of microscopic examination of rocks from oil fields of southeastern Ohio. M. I. GOLDMAN. 310.

Photometry. *"Average eye" for heterochromatic photometry. E. C. CRITTENDEN and F. K. RICHTMYER. 264.
†Normal eye for photometry of lights of different color. A. H. TAYLOR. 17.

Physics. †Calorimeter for determination of latent and specific heats of fluids. N. S. OSBORNE. 22.
†Elastic strain, effect of, on equilibrium temperature of a solid and its liquid. E. BUCKINGHAM; E. D. WILLIAMSON. 79.
Elastic systems, the vibration frequencies of. M. D. HERSEY. 437.
†Liquids, constitution of. IRVING LANGMUIR. 474.
Luminescence measurements. N. E. DORSEY. 1.
*Mercury, freezing point of. R. M. WILHELM. 13.
*Mercury vapor pump, two-stage. H. F. STIMSON. 477.
†Polarized light, application to the study of opaque substances. F. E. WRIGHT. 473.

Radiation, gray, criteria for. P. D. FOOTE. 573.
†Relative sensibility of the average eye to lights of different colors. W. W. COBLENTZ. 17.
*Sensibility of average eye to light of different colors. W. W. COBLENTZ and W. B. EMERSON. 427.
†Solubility, influence of non-uniform pressure on. J. C. HOSTETTER. 79.
*Specific gravity balance for gases. J. D. EDWARDS. 160.
†Specific heats at high temperatures. W. P. WHITE. 21.
*Thermometric fixed points, standard samples for. 561.
Viscometers, calibration of. E. C. BINGHAM and R. F. JACKSON. 53.
Visibility equation derived from the Ives and Kingsbury new luminosity equation. P. D. FOOTE. 317.
References. 466.
See also: Astrophysics; Biophysics; Crystallography; Electricity; Electrochemistry; Geophysics; Magnetism; Metallography; Optics; Photometry; Physical Chemistry; Pyrometry; Radiation; Radiotelegraphy; Spectroscopy; Technology; Terrestrial Magnetism.

Physical Chemistry. Autoclave, a convenient form of. G. W. MOREY. 205.

Plant Physiology. †Influence of cold in stimulating growth of plants. F. V. COVILLE. 394.
References. 496.

Pyrometry. The proper type of absorption glass for an optical pyrometer. P. D. FOOTE, F. L. MOHLER, and C. O. FAIRCHILD. 545.

Phytopathology. †Blister rust of white pine, control of. HAVEN METCALF. 313.
†Blister rust of white pine, technique for study of. R. H. COLLEY. 314.
*Crown gall, mechanism of tumor growth in. E. F. Smith. 187.
†Introduction of foreign plant diseases. R. K. BEATTIE. 168.
References. 492.

Radiation. *Emissivity of tungsten filaments. W. W. COBLENTZ. 426.
*Luminous radiation from a black body. W. W. COBLENTZ and W. B. EMERSON. 542.
*Planck's radiation equation, calculation of the constants of. H. M. ROESER. 542.
†Radiometers, characteristics and sensitiveness of. W. W. COBLENTZ. 164.

Radiotelegraphy. Notes on the audion. L. W. AUSTIN. 487.

Spectroscopy. *Helium spectrum, wave-length of the stronger lines. P. W. MERRILL. 393.
†Interference measurements of wavelengths, and infra-red spectrum photography. W. F. MEGGERS. 237.
†Spectroscopic field light. F. E. FOWLE. 238.
*Wave-length measurements in spectra from 5900 Å to 9600 Å. W. F. MEGGERS. 585.

Technology. *Aneroid calorimeter for specific and latent heats. N. S. OSBORNE. 426.
*Durability of stucco and plaster construction. R. J. WIG, J. C. PEARSON, and W. E. EMLEY. 16.
*Emulsification, resistance of an oil to. W. H. HERSCHEL. 137.
†Expansion, interferential method for measuring. I. G. PRIEST and C. G. PETERS. 475.
*Gas density, effusion method of determining. J. D. EDWARDS. 428.

†Gas density, rapid determination of. J. D. EDWARDS. 475.
*Glasses for protecting the eyes from injurious radiations. W. W. COBLENTZ and W. B. EMERSON. 268.
*Recovery of paraffin and paper stock from waste paraffin paper. W. H. SMITH. 39.
*Temperature measurements in Bessemer and open hearth practice. 464.
References. 42, 470.
Terrestrial Magnetism. References. 466.
Zoology. †Corals growing along the coast of Delaware. G. W. STOSE. 432.
Crinoid family Antedonidae, interrelationships of the constituent subfamilies and genera. A. H. CLARK. 504.
Crinoid family Antedonidae, revision of. A. H. CLARK. 127.
Crinoid family Bourgueticrinidae, revision of the recent genera. A. H. CLARK. 388.
†Fishes, a mortality of, on the west coast of Florida. H. F. TAYLOR. 166.
†Lower vertebrates, rate of growth. W. P. HAY. 394.
†Mammals, origin of. J. W. GIDLEY. 196.
†Mollusk collecting in the Philippines. PAUL BARTSCH. 25.
†Mud-turtle, hibernation of. ALEXANDER WETMORE and FRANCIS HARPER. 315.
†Pioneer naturalist of southern Florida,—Titian R. Peale. T. S. PALMER. 201.
†Poisonous snakes. M. W. LYON, JR. 46.
†Porpoises and steamers. WILLIAM PALMER. 240.
†Shad and its relations in the Mississippi River. EMERSON STRINGHAM. 201.
†Tardigrade, new species of. W. P. HAY. 45.
†Trunk-fishes, notes on. R. W. SHUFELDT. 201.
†Zoological statuary at the National Capital. R. W. SHUFELDT. 273.
See also: Economics; Entomology; Genetics; Mammalogy; Medical Zoology; Ornithology.

ANNOUNCEMENT OF MEETINGS OF THE ACADEMY AND AFFILIATED SOCIETIES[1]

Saturday, December 22: The Philosophical Society, at the Cosmos Club, at 8.15 p.m. Program:

E. D. WILLIAMSON AND L. H. ADAMS: *Measurement of the compressibilities of solids under hydrostatic pressure up to 12000 megabars.* (Illustrated.) 30 minutes.

N. S. OSBORNE AND M. S. VAN DUSEN: *Latent and specific heats of ammonia.* (Illustrated.) 30 minutes.

Saturday, December 29: The Biological Society, at the Cosmos Club, at 8 p.m.

Friday, January 4: The Botanical Society, at the Cosmos Club, at 8 p.m.

[1] The programs of the meetings of the affiliated societies will appear on this page if sent to the editors by the thirteenth and the twenty-seventh day of each month.

CONTENTS

Original Paper

Page

Oceanography.—An instrument for accurate and rapid density measurements on board ship. A. L. Thuras 605

Index

Author index 613
Subject index 623